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Notes on Great Tunnels.*

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Mr. President and Members of the Institute:—

Tunnels, like bridges, are engineering devices for overcoming physical obstacles to traffic.

Although of ancient origin their recent great development is the outcome of the demands of modern civilization resulting from the increase in population and commerce.

The advent of railroads in 1827 gave an impetus to the building of tunnels to save time, distance and grade in the interchange of traffic. These "horizontal wells," as they were called, were excavated by hand labor, as they were comparatively short, but with the increase of tonnage and demands for greater economy in cost and time, more pretentious enter-

*Revised for publication.

prises were undertaken, requiring the use of machinery and power for their completion. Thus the ingenuity of man was impressed to meet the difficult requirements of providing an unobstructed passageway through mountains or under rivers or city streets, in the least time and at a moderate cost.

It was not until tunneling machinery was reasonably perfected that long tunnels without shafts became at all practicable for transportation, although there were several constructed at enormous waste of time and labor, for drainage purposes.

The introduction of efficient drills may be said to date from the first American patent, issued to J. J. Couch, March 27, 1851, for a reciprocating, hollow piston-rod, working in a cylinder, operated by steam, but it had a constant feed and no provision for the rotation of the bit. He took out a second patent November 3, 1852, for some improvements, but in the meantime Stuart Guynn was busy on independent lines in applying the same idea in a practical machine,—also having a constant feed,—but it slumbered from 1851 until the contractor of the Hoosac Tunnel, in Massachusetts, Herman Haupt,* embodied with this hollow piston-rod an automatic feed and rotating device which produced a simple, light and effective drill capable of piercing granite at a rate of one inch per minute and weighing only about 125 pounds. In ordinary shale the speed was doubled. It was estimated that with this tool a progress of twelve feet per twenty-four hours could be made at a cost of $16.33 per lineal foot of single track (15x18), or at about half the price of hand work, and with four times the speed.

To prevent the loss of time in clearing the heading from the debris and gases incidental to blasting—as well as to facilitate the drilling of the holes—a system was devised by the contractor whereby the drills were mounted in series of three or four on columns, which served both as supports and feed pipes for power (steam or compressed air). Thus mounted the drills had a large range in altitude or azimuth, as shown in Fig. 1. The jacks for clamping the stanchions in position and the ball and socket joint at the bottom of frames enabled the bits to be readily changed without removing the gang. The plant also included a low counterpoised derrick

*Died December 14, 1905.

and truck, enabling the gangs of drills to be rolled to the rear of the heading, which was driven at the bottom. Prepared cartridges were placed in the holes, and held by a plug, wired in series, and discharged by a hand battery, simultaneously. A vacuum fan and conduit laid on the floor soon relieved the heading of foul gases, and the drills were rolled forward, set up, coupled and started without awaiting removal of débris. To protect men and machinery a section of heavy timbers laid on the floor was hoisted by a bell-crank lever to an

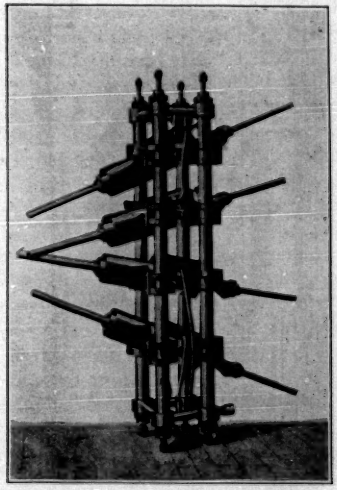


Fig. 1

upright position to serve as a screen during blasting. These several features are clearly shown in Figs 2 to 4, which also illustrate the auxiliary steam plant with tender, when that motor is found to be more expedient.

Modification of this pioneer rock drill were made by Burleigh, DeVolson Wood, and others, to adapt them to the ever varying requirements of the service, and have led to the extensive manufacturing plants of the Ingersoll-Rand, and

Fig. 2

Fig. 3

Fig. 4

other companies for supplying complete outfits of tunneling and mining machinery now in common use for all classes of excavations in hard materials.

The contract price for this tunnel was $2,000,000, while the cost was $50 per lineal foot, or for the full length nearly $1,300,000. It was the purpose of the contractor not to use a shaft but to drive from the ends on a rising gradient and ultimately, when the traffic increased sufficiently, to open a parallel tunnel by means of galleries from the first, at frequent intervals, thus greatly reducing the cost, improving the ventilation and avoiding lining. The State, however, saw great political possibilities in this enterprise, and by a change of administration, during the civil war, its control was assumed by the Commonwealth, the dimensions were changed to double track, a large dam built for power, and other radical departures made, which swelled the cost to about $10,000,000, or five times the amount of the original contract. A shaft was sunk 1028 feet in depth, which was of little use in expediting the work and was of doubtful utility. This Hoosac Tunnel of five miles in length, the longest in the United States at the time, was simultaneous with that under Mt. Cenis, where a compressed air plant, operated by water-power, was installed by Mr. Sommellier, the experience from which was a factor in the designing of the plans for the Hoosac, and this in turn, for works of the present day. The close relations of the several long railroad tunnels will become more apparent by a brief chronological statement of their statistics and time of construction.

I. HOOSAC, MASS.

Work was commenced in 1854 and prosecuted by private contractors until the State took possession, September 4, 1862. It was enlarged, and completed July 1, 1876, when it was officially accepted. The total cost of the railroad and tunnel, forty-four miles, was $17,322,019, of which $3,287,835 was interest. The progress was greatly accelerated by the introduction of power drills, 1867, and of nitro-glycerine, in 1870, which was manufactured by Geo. W. Mowbray, in the vicinity of North Adams. This gives an average progress of 5.5 feet per diem.

2. MT. CENIS.* THE ALPS.

The project was first broached by Guisseppe Medail, a Swiss peasant, in 1838, and subsequently, in 1852, M. Colladou suggested driving it by the use of compressed air drills, operated by water-power, but it was not until 1857, after a report by experts, that the Piedmontese Parliament granted a charter and agreed to pay half the estimated cost, which was $7,760,000, but it ultimately paid for the entire work.

The first blast was fired August 18, 1857, and the headings met December 25, 1870. It was opened for use September 17, 1871. It was double-track, driven with bottom heading $9\frac{1}{2}$x$8\frac{1}{2}$ feet. Average rate of progress, 8.00 feet per day. Total length, 42,158 feet, or 8.0 miles. Time, fourteen years in building. Cost, $14,498,352. Machine drills were introduced at the north end in 1861 and at the south end in 1863. The last year the rate was $14\frac{3}{4}'$ a day.

3. SUTRO TUNNEL.

The third long tunnel built was designed to open up the famous Comstock lode, in Nevada, by providing better drainage and greater accessibility to the mines. The section was 12x16 feet and length 20,351 feet, or nearly four miles. Work was begun October 19, 1869, and completed about 1878. There were four shafts designed to be used in construction, three of which were over 1000 feet deep, but two of them were abandoned before reaching grade because of the great influx of water. Progress per day (1875) in heading (10x8) was 10.24 feet.

4. ST. GOTHARD. ALPS (1872-81).

At the St. Gothard tunnel the Sommellier drills were used for a few years but were supplemented by those of McKean & Ferroux, making about 180 blows per minute. These McKean drills were modifications of the system designed for the Hoosac Tunnel and taken to Europe by Blanchard & McKean, agents for the contractor.

The contract for the St. Gothard was awarded to Mr. Louis Favre, August 7, 1872, at an estimated cost of $10,000,000, and

*Drinker's Tunneling, p. 266.

was completed in eight years, with a premium of $1000 per diem for every day saved or a similar penalty for each day lost. With the system of rapid firing and removal of débris great progress was made in each heading, and the work was opened in 1880—the first train passed through in 1881.

Its total length is nine and one-quarter miles; time, nine years, five months, and average daily progress, 14.6 feet, notwithstanding great difficulties from water and the caving of the lining. The early location of the approaches was placed high on the mountain slopes instead of the valley bottom, adding

Fig. 5

much to the expense, but this was afterward modified by the use of the spiral tunnel and loops. See Fig. 5.

THE ARLBERG TUNNEL. ALPS (1880-84.)

Through the Austrian Tyrol a tunnel of 6.38 miles was driven between 1880 and 1884 at a much more rapid speed than any of its predecessors, at an estimated cost of $7,000,000. The time consumed was three years, nine months, and the average rate of progress 27.8 feet per diem. Work was conducted very systematically and construction trains were run by time sched-

ules. The headings, which were 7.5 feet high and 9.2 feet wide, were placed at the bottom instead of the top of the tunnel. In cost, therefore, this work was but $1,000,000 per mile, $208 per foot, and in speed of execution three times as fast as Mt. Cenis.

THE SIMPLON. 1893-1905. 12¼ MILES LONG.

This tunnel, which connects Brig, in the Valley of the Rhone, with Iselle, on the Diveria, in Italy, is twelve and one-quarter miles in length. The contract was let in September, 1893. The plans contemplated the use of the system proposed for Hoosac of two single-track parallel tubes 16.5 feet wide, 55.7 feet apart, but connected by oblique galleries at frequent intervals. Only one of them was to be completed to full dimensions, while the second was to be used for subsidiary purposes to provide trackage for construction and ventilation, and to await the demands of traffic for its final enlargement. The cost is reported to be $15,500,000 to February 24, 1905, when the headings met, thus opening the shortest route by eighty miles between Paris and Milan, and connecting the Atlantic and the Mediterranean. The large amount of water and high temperature (reaching 118°F.) made this work one of unusual difficulty.

Actual work was begun in 1898, so that the average ratio has been nearly two miles a year, and it is a monument to the enterprise and energy of the countries which have contributed so liberally to the colossal work which at best will save but a few hours in transit between the Italian seaports and the British Isles. (For difficulties from hot springs see Scientific American of March 18 and 25, 1905.)

SUBWAYS.

The feature of the above works is that they have generally been excavated from the ends, without intermediate shafts or slopes. Many more miles of continuous underground ways are now in existence, as in the numerous subways of Continental and American cities, but these have been built largely as open cuts or covered-ways, or with numerous shafts.

SUB-AQUEOUS.

Another important class of structures is the sub-aqueous passages connecting great centers of industries and taking the place of bridges. These involve greater difficulties and risks than are to be found in the previous classes, yet to avoid the transfers, delays and risks of ferries or the obstructions due to bridges, ice and fogs, they are found to be expedient, even at very great cost.

The latest and best practice in works of this kind is illustrated in the extensive system of tubes now completed and under construction by the Pennsylvania Railroad Company, under the direct supervision of Mr. Chas. M. Jacobs, Alfred Noble and others, in and across the rivers surrounding the Island of Manhattan, and connecting its western ramification directly with the greatest seaport of the continent, without break of bulk.

Whilst the tube-system as used underneath the North River at New York has required much ingenuity to adapt it to its purpose, the general idea was first applied in the pioneer work built under the Thames, at London, by M. I. Brunel, in 1825 to 1846. This structure is 1200 feet long, with two passageways 14 feet wide by 16½ feet high, and is now used by the East London Railway.

The influx of mud and water were so great as to cause the invention of a shield to cover the whole face of the excavation, 38 feet wide and 22½ feet high. An attempt was made to introduce the Beach pneumatic system in New York about the year 1863, but it was untimely, and the traffic had not at that time reached such magnificent proportions as to justify the expense, and there was an aversion to being shot through a hole in the ground by the public. Electric motors were not then available. Again, in 1868-69, W. H. Barlow used a modified form of Brunel's shield in building the "Tower" subway under the Thames. This was circular in section, eight feet in outside diameter, and was lined with ribbed cast-iron plates. It was the prototype of the present generally adopted system. In 1889, a pair of tubes, each ten feet in diameter, was laid under the Thames by Mr. Greathead for the South London Railway by means of an improved shield telescoped over the outer end and pressed forward by jacks, as in the Tower subway.

The earliest sub-aqueous aqueduct tunnels in this country were those built at Chicago in 1864-67, two miles long, at a cost of $457,844, and subsequently extended four miles further for a fresh water supply. A second conduit eight feet in diameter and four miles long was added in 1887-1892, and also at Cleveland in 1869-74, when a conduit five feet in diameter and 6,606 feet long was built.

In 1888-1902, the Grand Trunk Railroad built a single-track circular tunnel, lined with cast-iron segments, by the use of shields, under the Detroit River, at Sarnia, through soft clay, sand and gravel 6000 feet in length. To-day similar systems of sub-aqueous tunnels are being rapidly and successfully built under the North and East Rivers.

AQUEDUCTS.

Still another extensive group of tunnels is to be found in the aqueducts for supplying large communities with water. The most conspicuous example of this class is the Croton Aqueduct of thirty-three miles in length and about fourteen feet in diameter, crossing the Harlem River by means of an inverted syphon at a depth of 306 feet below the surface.

DRAINAGE TUNNELS.

Amongst the most interesting works of this class may be mentioned the ancient Desague de Huehuetoca, undertaken by Enrigue Martinez, a Dutch engineer, in 1607, for draining the basin of the City of Mexico. The tunnel was four miles long and the drain thirteen, but before the lining was completed a great flood caused it to cave in. As a reward for his effort the engineer was imprisoned for three years, and when released he was ordered to make an open cut, in which he spent the rest of his life. But the work was continued for 120 years, yet it was not made deep enough to relieve the basin to any great extent. In 1888, another tunnel was built six miles long and 150 square feet in section, supplemented by twenty-seven miles of large canals, this tunnel had twenty-four shafts, varying in depth from 75 to 325 feet and a discharge capacity of 450 cubic feet per second, and furnishes an excellent precedent for the problem now confronting the Isthmian Canal Commission en-

gaged in the regulation of the floods of the Chagres River at Panama, where the success of the enterprise is made to depend upon the diversion of these torrential waters by means of tunnels from seven to ten miles in length through the Cordilleras. But in this case little is known of the geology or stratigraphy, and as to the possibility of any shafts being used.

Before closing these brief remarks it may be found expedient to glance at the attitude of the traffic problem in this city in 1888 as contrasted with present conditions. Then the necessity of additional facilities was urged by the official publications of this Institute, but was opposed by the vested interests handling the interurban traffic, because of the extreme cost of such works and terminals; of the "impossibility of satisfactorily operating the subway;" because "the subway car motor connected with the other lines of the road;" because "it would be unwholesome and unsatisfactory to the public;" because "it would forever preclude the growth of business on the lines of the company and prevent any extensions in the future to meet increased business," and lastly, because "the destruction of the railroad's terminal facilities in Philadelphia would entail a loss* impossible to estimate."

That these objections were untenable is evident from the fact that the "impossible" has vanished, and the underground and elevated roads have come to stay. Councils are now considering the necessity of abolishing all grade crossings and the steam routes are cheerfully asquiescing, while the city and railroad engineers are harmoniously working to relieve the surface from all rapid transit trains, as is best for the interests of all parties.

The Market Street subway contracts for sections 3 and 4, extending from Fifteenth Street west to the Schuylkill River, were let to E. E. Smith on April 1, 1903, and the work, which was begun April 6,, has been vigorously prosecuted so that it is expected to be open for traffic this year (1905). It is designed for four tracks, two of which will carry express trains to connect with the elevated railroad building out Market Street from the east side of the Schuylkill to Delaware County. The four track bridge across the river is now well under way. The local or

*See rapid Transit in Cities, Jan., 1888, Journal of F. I.. Feasibility of Underground Railroads, Dec., 1888, Journal of F. I.

outer tracks will make a loop at the eastern end, passing down Fifth to Walnut, thence to the River Delaware, to Arch, to Fifth and return to Market. The dimensions, in the clear, are 48 feet 6 inches in width and 14 feet 6 inches in height from top of rails. The roof girders are supported by three rows of steel columns. The side walls are of reinforced concrete, and the work is being carried on without seriously interrupting local traffic.

Stations are placed at Fifteenth, Nineteenth and Twenty-fourth Streets.

Chicago has already constructed some twenty-eight miles of freight and passenger subways at a rate of twenty-one feet per day from each of the fourteen headings, the material being firm clay (See Scientific American, March 11, 1905) giving the unprecedented rate of progress of twelve miles in less than a year.

Boston has built a much-needed underground transit way, which is very popular and which has to some extent relieved the congestion of the surface, and the great work in New York goes rapidly on, but it is demonstrated that by the time one system is completed the increase of traffic has reached the limit of its capacity and another is demanded, so that to-day applications are being made for new charters under additional streets.

In view of the record of the past it is reasonable to look for the construction in the near future of the long-projected tunnels under the Straits of Dover to connect the British Isles with the Continent by a continuous line of rails, and the project of M. Lobel under Behrings Straits to join Alaska and Siberia, and thus furnish an all-rail overland connection between New York and St. Petersburg or Paris, or even with Cape Town in Africa, via the Cape to Cairo route.

These are some of the transformations which the engineers of the future may effect in the traffic routes of the world, through the instrumentality of great tunnels made practical by improved drilling machinery.

For further details see "Tunneling," by Henry S. Drinker. Johnson's Encyclopœdia article Tunnels, by Wm. R. Hatboro. Tunneling by Machinery, Herman Haupt, 1867.

The Economic Future of Japan.

By Mr. Achille Viallate.

Professor in The Free School of The Political Sciences at Paris, in Conference with The Société Industrielle de Mulhouse.

Translated from the April, 1905, Bulletin of the Société, Séance of February 22d, 1905, by Chief Engineer Benjamin F. Isherwood, U. S. Navy.

Japan was made known to Europeans for the first time by the writings of the Venetian traveller, Marco Polo, in the Thirteenth Century. Regular relations, however, were only established between the Occidental Powers and the Empire of the Rising Sun three centuries later, towards the middle of the Sixteenth Century. In 1543, a Portugese adventurer navigating along the Chinese coast, was driven by a storm upon the coast of Japan, where he landed. Following the Portugese came the Spanish—masters of Manila—and then came the Hollanders and the English, each in turn seeking commerce with Japan. This traffic had, with difficulty, began to acquire some amplitude, when the Japanese Government brusquely closed its dominion to foreigners. The edict of 1638 interdicted them, with the exception of Chinese and Hollanders, from trading, and restricted these latter two to the small island of Desima, in the Bay of Nagasaki. Also, the Japanese were forbidden, under penalty of death, from leaving their country.

During two centuries Japan continued to live an isolated life. The ardent desire of Europeans for a renewal of commercial relations which they hoped would be profitable, menaced, from the commencement of the Nineteenth Century, this isolation. In 1824, the English appeared at Mito; and in 1846 an American squadron vainly attempted to open negotiations with the Japanese authorities. The Americans returned in 1853, and in the following year Commodore Perry obtained, by means of the fear which his cannon inspired, a treaty of peace and amity between Japan and the United States, together with the opening

of the ports of Shimoda and Hakodate to American commerce. A little while afterwards Great Britain and the other European powers compelled the signing of treaties giving them the same advantages. In July, 1858, the United States concluded a treaty of commerce which provivded for the opening within three years of five additional ports, and limited the maximum tariff; the tariff of importation was not to exceed 20 per centum, *ad valorem*; and the tariff of exportation was not to exceed 5 per centum. By new conventions made in 1866, Japan engaged to limit to 5 per centum, *ad valorem*, the tariff of importation. By means of the insertion into all the treaties made by other powers with Japan of the clause of the most favored nation, the advantages obtained by any one of them becomes extended, *ipso facto*, to the others, and all Europeans are thus placed in an analogous situation.

The concluding of these treaties hastened a political revolution which ended in the destruction of the feudal system prevailing up to this time in Japan. The Emperor regained the power of which for more than three centuries the Shogun had dispossessed him. In 1881, an imperial ordinance established the representative system, and in 1889, the Emperor granted a constitution to his people, in which he remains the supreme authority, but delegates a part of his powers to a Diet, composed of two Chambers: the Ministers remain responsible to him alone.

Modernized Japan endured with discontent the treaties of the period between 1854 and 1866, which gave to foreigners the rights of exterritoriality in the open ports, and made them answerable to only the Consular tribunals. In 1894, England, and, afterwards, the United States; then, Russia in the following year; Germany in 1896; and, then, France; consented to the substitution for the old treaties, of new ones satisfactory to the Japanese. After the making of these treaties, which became operative on the 4th of August, 1899, and which now actually regulate the relations of Japan with foreign powers, the latter abandoned their privilege of national jurisdiction; they also surrendered to Japan the elaboration of its own tariff with reservation of the conventional rights defined by these latter treaties. On the other side, Japan has opened its entire territory to foreigners.

Japan has not limited its innovations to the Europeanizing of its political institutions. It has with great boldness undertaken a profound economic transformation that has caused serious disquiet to the rest of the world.

What, then, are these efforts now being made by modernized Japan in the evolution of its economic system. What causes exist from which their success may be inferred in the future? Has Japan truly the necessary elements for becoming a great industrial power? Up to what point has other nations to fear the advent of this new competitor? Such are the questions which are proposed to be briefly answered in this paper.

I.

The Empire of Japan consists of a long chain of mountainous islands or volcanic origin, extending from mid-Kamtchatka to Formosa, which island was taken from China at the close of the war of 1894. It is formed, exclusive of Formosa, which is a colony, of four large islands, "Hokkaido," "Honshu," "Shikosu," and "Kiushu," and of 600 small islands. Its surface is about 147,500 square miles. Excepting "Hokkaido" and the north of "Honshu," which, because of their latitude, are subjected to rigorous cold, the rest of the Empire has a temperate and humid climate.

The population has rapidly increased. From 33,000,000 in 1872, it rose in 1903 to 46,000,000.

The Japanese remain to the present time almost wholly an agricultural people, notwithstanding that the country is but little adapted for agriculture. The arable land is only 15.7 per centum of the whole surface of the Empire. Of this whole 45 per centum (the low flat ground) is utilized for the cultivation of rice; and 38 per centum (situated on the sides of the hills) serves principally for the tea plantations, and for the plantations of mulberry trees, the leaves of which are used as food for the silk worms.

The food of the Japanese is principally rice and fish.

The agricultural population is estimated at 23,000,000 of persons. The predominant character of the cultivation is the small scale on which it is practiced. The work is almost wholly done by hand. The implements are mediocre, and often not of metal.

The productive capacity of the worn-out soil is maintained by constant labor, a very careful irrigation, and the abundant use of manures. By these means, two, and sometimes even three, crops are obtained during the year from the same ground.

Notwithstanding all efforts, agriculture with difficulty supplies the needs of the population, the rapid increase of which is a most disquieting problem for the Japanese Government. The least deficit in the rice crop compels recourse to importation.

The agriculture of Japan, though still very backward, can hope for great improvement, to accomplish which the agriculturists, now entirely guided by tradition, must be properly instructed, and the necessary money for the desired ameliorations must be provided, because they are so ignorant and so poor.

The government is applying itself to this double task by supplying agricultural teaching, and by creating financial institutions for agricultural credit. But whatever may be the efforts made and the results obtained, the progress of agriculture will be fatally limited by the small extent of territory susceptible of cultivation. Doubtless, the sides of the hills having a moderate inclination are capable of cultivation, but they represent only 8 per centum of the total surface of the country, so that the most optimistic previsions cannot hope the Empire of Japan will ever be able to devote more than 25 per centum of its area to the production of food.

* * *

The Japanese agriculture of the present day does not differ much from what it was before the Revolution; but the case is quite different with industrial Japan, for here the progress made in thirty years has been considerable. The Japan of 1870 knew only the industries that could be practiced by the household or in small workshops, and was ignorant of all the modern methods of production. The tools were rudimentary, and the only motor employed was water-power.

Industries on the great scale are to-day established in Japan. Their progress has been rapid. In 1894 only 1808 steam-engines developing an aggregate of 32,808 horse-power were employed. In 1902 the number of steam-engines returned was 4,057, developing an aggregate of 90,778 horse-power. In the suburbs of the large cities, "Tokyo," "Kyoto," "Osaka," etc.,

formerly dominated by the traditional low buildings of wood, now rise the vast brick constructions and the lofty chimneys of the modern factory.

Like the political transformation, the industrial transformation is the work of the statesmen who have made modern Japan. With that country remaining completely isolated from European movement, to count upon private initiative to introduce the modern methods of production, was impossible. The government of the Revolution, conscious of the task imposed upon it, sent to Europe and to the United States missions charged to study the industrial methods of those countries, and it also obtained from them experts for organizing such of those industries as seemed the most pressing.

Mining was on an ancient system. The government employed foreign engineers to introduce into this industry the modern processes of exploitation.

The ministers of war, of the navy, of the treasury, became ministers of the corresponding industries, and thus played the part of veritable educators. The first undertook the manufacture of powder for cannon, and of the material of war. The second created a dockyard and workshops for the construction of small vessels, and for the reparation of the large ones that during several years he was obliged to buy from foreigners. To furnish the castings for these purposes a foundry was put in operation.

The minister of the treasury needed a mint, and this required an establishment for making the assays. He desired to manufacture, according to the methods of Europe and America, the material for the paper money issued by the State, and for the notes issued by the banks, and for the postage stamps. For these purposes he was obliged to create a paper making factory, a manufactory of sulphuric acid, of soda, etc. The government having undertaken the construction of railroads, had to manufacture cement.

In 1872, he established at Tourioka (Gummakin) a model spinning mill, with the view of introducing machine-spinning in the silk industry. In 1877, he created at Senju, near Tokyo, a weaving mill for wool. In 1881, he erected model spinning mills for cotton at Nukada-Gun and at Aki-Gun; and he sold, on credit, looms bought in England, to private persons living in

different cities in order to spread this new industry. In 1876, he founded a glass-making factory at Shinagander.

The government having thus given the impulse, abandoned the part of initiator which circumstances had compelled it to assume, as soon as private interests in their turn commenced to follow in the way shown by it and in which it still guided them. Commencing in 1880, it sold, one after another, its model establishments to private industry; but it retained, nevertheless, the workshops necessary for the needs of the army, and of the navy, and of some other departments of the State.

At the same time that the government was creating modern industries by the aid of foreigners, it commenced the creation of technical education for its own people.

The efforts of the Japanese government have been crowned with success. Without doubt the old industrial methods still exist; the family industry has not ceased, and numerous industries are operated in an incomplete manner; but the great modern industries, using mechanical tools, and steam-engines for driving them, together with their scientific methods, have taken firm root in Japan, and are extending farther and farther every year.

In 1902, there were 2,427 manufacturing companies, with an aggregate capital of $86,500,000; and in 1898, establishments employing over thirty persons each, had an aggregate personnel of 506,912.

The following statistics enable an idea to be formed of the industrial development during the last decade, and of the actual situation.

PRODUCTION OF SOME MINERAL MATTERS.

	Coal tons.	Iron. tons.	Copper. lbs.	Petroleum. gallons.
1892	3,200,000	18,500	248,400	4,491,400
1902	9,700,000	31,400	350,400	41,743,600

WORKSHOPS AND FACTORIES WITH MOTIVE POWER.

	Steam Power		Water Power		Steam and Water Power	
	Number	Horsepowers	Number	Horsepowers	Number	Horsepowers
1894	1098	32,858	1690	2,429	221	5,744
1902	2449	90,778	497	5,298	45	4,825

PRODUCTION OF THE PRINCIPAL INDUSTRIAL ARTICLES.

	Raw Silk. Pounds	Waste Silk. Pounds	Tissues. Dollars	For Exportation Straw Goods. Dollars	Porcelain and Faience. Dollars
1892	9,064,700	4,320,700	24,500,000	282,000	1,881,000
1902	14,827,500	6,303,800	75,500,000	2,631,000	3,455,000

	Lacquered Articles. Dollars	Beer. Gallons	Chemical matches. Dollars	Japanese paper Dollars	European paper Dollars
1892		333,500	2,500,000	2,500,000	500,000
1902	2,769,000	3,702,000	4,300,000	7,000,000	3,500,000

The greatest development has been in the spinning of cotton-thread industry, which has become a really great modern manufacture.

COTTON-THREAD.

	Number of factories	Capital engaged. Dollars	Mean daily number of employees	Raw Cotton used. Pounds	Cotton-thread manufactured. Pounds
1892	39	4,500,000	403,314	100,900,000	82,700,000
1902	80	17,200,000	1,301,118	365,500,000	317,600,000

Certain of the above industries have worked solely for the home market, but now they have commenced to work for the foreign market also, and exportation has made sensible progress.

EXPORTATION VALUE IN DOLLARS.

	1890.	1903.
Cotton goods	28,000	19,029,000
Silk goods	1,662,500	15,724,500
Coal	1,549,500	9,603,000
Chemical matches.....	744,500	4,236,500
Straw goods	173,500	2,325,500
Porcelain and faience.....	622,500	1,584,500
Cigarettes	4,000	1,023,500

* * *

The imperial government became occupied at an early date with the means of communication and of transportation.

In March, 1871, the postal system, organized in imitation of those of Western nations, was inaugurated between the cities of Tokyo, Osaka, and Kyoto, and was rapidly extended. In June, 1874, Japan joined "The International Postal Union." In 1879, it became a member of "The Universal Telegraphic System."

The first line of railroad was opened in 1872. It connected the cities of Tokyo and Yokohama, and was a governmental initiative. In 1883, private companies commenced the construction of railroads. In 1903, the extent of the system was 4,495 miles, of which 1,344 miles were built by the State. In the last decade the number of passengers has nearly quintupled, and the freight has more than decupled.

From an economic point of view, the organization of a national monetary system was not less important than the creation of the means of rapid transport. The imperial gov-

ernment was obliged to consider this problem several times before it reached a solution.

A law of November, 1869, decided to adopt the metric measures and with silver for the standard metal, as the basis of the imperial monetary system. The law of May 10th, 1871, modified this system by substituting the gold standard for the silver standard. The change was premature, and embarrassed the government, which was obliged to have recourse to paper money, and this both drove the metallic money out of, and prevented it from passing into, circulation. Previous to the failure of the law of 1871, the ordinance of the 11th of May, 1878, legalized the silver "yen," and without restriction of coinage. Theoretically, Japan passed into bimetalism; practically, it remained under an exclusively paper-money regime. In 1886, the return to specie payment was realized and became definitive; but the country remaining subjected, in fact, to an exclusively silver standard, suffered all the consequences of a gradual diminution in the price of that metal.

The war indemnity obtained from China in 1895, enabled Japan to adopt the gold standard. The law of the 26th of March, 1897, prescribed for the monetary unit the "yen" of the weight of two *fun* (0.75 grammes, centigrade) of pure gold, and, consequently, of an intrinsic value of 2.50 francs.

There is not in circulation any more paper money issued by the State. The sole existing paper money is the notes of the Bank of Japan, which bank was created in 1882 with the exclusive privilege of emitting them. It has an entirely paid up capital of $15,000,000, and issues notes payable in gold on demand, which notes have the quality of legal money.

Foreign commerce has had a rapid development. The aggregate of importations and exportations in 1872, was only $16,500,000; but in 1888, it surpassed $50,000,000. In 1894, it exceeded $100,000,000; and in 1903, it rose to $303,000,000.

More than 30 per centum of the total importations of Japan is food stuffs, which the insufficiency of its own agricultural productions compels it to obtain abroad; and 23 per centum is of material in the raw state; the cotton, wool and hemp necessary for its newly developed industries. The remainder is composed of articles of European manufacture, the consumption of which rapidly increases. Among these articles are

prime motors and power tools to the annual amount of $2,500,000.

About 34 per centum of the exports consists of agricultural products: raw silk, tea, camphor (from Formosa); and 11 per centum of mineral products, copper ore and coal. The surplus consists of manufactured products, of which the two principal ones are articles of silk and articles of cotton (for the major part of the cotton is in the state of thread), representing altogether about 23 per centum of the total exportation.

The greatest part of the commerce of Japan is with Asiatic nations—about 50 per centum of its importations and of its exportations. Its greatest sources for supplies are as follows: Great Britain, the United States, Germany; then, but a long way after, Belgium and France. Its best clients among the western powers, are: the United States, France, then Great Britain, Italy and Germany.

The Japanese Government is strongly endeavoring to create a national merchant marine. Since 1870, it has subsidized marine construction. The laws of 1896, which regulated anew the bounties for construction and for navigation, have been largely increased. The results obtained are important. The total tonnage of the merchant fleet (steamers and sailing vessels) of the European type, has risen from 77,000 tons in 1879 to 225,000 tons in 1893, and to 919,000 tons in 1901. At this latter date, the number of steamers was 1395, measuring an aggregate of 583,000 tons, of which number 969 measured in the aggregate 577,000 tons, counting among them 67 which measured between 2000 and 5000 tons each, and 22 among them which exceeded 5000 tons each.

Following the example of the western powers, Japan desired a Postal Company, with rapid steamers, and for that purpose subventioned the "Nippon Yousen-Kaisha." This company, just previous to the war with Russia, which disorganized its service, had made six regular departures per month; once a fortnight for Europe and for America, and once every four weeks for Bombay and for Oceanica.

Up to 1883, the part taken by the Japanese flag in the foreign commerce of the country was nearly nothing. Since then, it has increased rapidly, rising to 10 per centum in 1890, and to 30 per centum in 1900.

II.

The progress made by Japan in the short time of thirty years, has indeed been very considerable. She surprises us simultaneously by the importance of that progress, and by the decision and spirit with which her government commenced and continued the economic transformation of the once merely agricultural Japan into the present industrial Japan, equipped with western knowledge, and eager to compete with western nations in the markets of the world. The statesmen of the Revolution had the intelligence to perceive promptly and clearly that a pressing economic necessity compelled Japan to become, and at once, a great industrial power, and that only under this condition could she achieve the political destiny for which she was ambitious.

With its agricultural territory narrowly limited by the physical configuration of its soil, Japan already could not feed its population; and to become an industrial nation was a vital necessity. Only in the development of its manufacturing industries could be found the lacking elements of wealth. And to become a great political power; to play the role that it wished to play in the Extreme-Orient; to make itself the guide in the path of western material civilization for the Oriental peoples; to substitute its protectorate for those which European nations were attempting to impose on them; there was an equal necessity for Japan to become a great industrial power.

But has Japan truly the many indispensable elements for becoming a great industrial power? Will it not encounter obstacles that will obstruct or arrest its course? Is the competition with which it menaces the industries of the Ocident as redoubtable and as near as has been proclaimed by many European publicists?

To form an opinion on that point, an examination must be made of the conditions of Japan relatively to the abundance of its prime motors and raw materials, and to the facility with which it could find the necessary capital for the erection of so vast an edifice. Finally, there must be known the personal qualities and defects of the captains and of the troops of its industrial army.

The subsoil of the Japanese Empire is not yet sufficiently

known to appreciate with any degree of exactness its deposits of coal; but the basins of Kyushu, of Hokkaido, and of Hitachi-Iwaki, the exploitation of which is still far from being complete, assures a sufficient quantity of fuel for a long period. Should this be an error, coal from the Chinese mines can be cheaply procured, and would add considerable resources. Petroleum is another fuel which nature seems to have as liberally bestowed. There is thus a nearly inexhaustible reserve of motive power. Also, the numerous waterfalls along the coasts of Japan will become a precious advantage to its industries.

Japan is less favored in the matter of raw materials. In that respect, there is abundance only of silk; but the location of the country permits it to cheaply procure all the others it may need. Well endowed as regards copper, it appears to be less so as regards iron; but of the latter it could obtain large quantities in China.

The southern islands of Japan still cultivate cotton, but this crop, little remunerative, is diminishing instead of increasing. The Japanese industries import their cotton ordinarily and cheaply from British India and from China. Formosa will, without doubt, be in a few years the center of an important production. As to American cotton, the completion in two or three decades of the Panama Canal, will enable it to be imported under excellent commercial conditions.

As regards wool, the difficulty of raising sheep, notwithstanding the attempts hitherto made, seems insurmountable. But, on the other hand, the Japanese are no farther than the Europeans from the great producing centers of Australia and of South America.

Thus, in what concerns motive power and raw materials, Japan will encounter no extraordinary obstacles. It has not to fear any impediments that could long arrest its progress.

The question of capital offers a more delicate problem. Japan cannot find among its own people sufficient resources for the building of factories with which to create large industrial enterprise still in embryo, much less can it progress rapidly. The paucity of capital for such purposes is a serious matter, and the money will have to be obtained abroad. Now, it will have to overcome among the capitalists of the

West, an apprehension that exists there at present with regard to such loans, and which nothing has thus far lessened.

It ought, if it does not wish to cripple its industrial progress, to facilitate the coming of capital into the country by granting to foreign capitalists guarantees which the Japanese Legislature has, up to the present time, refused to do.

The question of the personnel—captains of industry, leaders of enterprises, agents, superintendents and foremen, the mass of workmen—is the gravest that confronts Japan in what concerns its development. Herein it will encounter the most serious obstacle, if not the stumbling-block, capable of arresting, or, at the least, of sufficiently hindering, the course of its economic transformation to prevent the accomplishment of its grandiose projects.

Pure science, vast hypotheses, seem repugnant to the Japanese mind. It lacks invention, and closely follows the European lead. But if the Japanese are deficient in genius, they have, on the contrary, the talent of imitation strongly developed, and they very quickly acquire the industrial methods originated by others. And, certainly, the directing classes among them have other qualities more important at the present era than formerly from the economic point of view by reason of the already great development of mechanism, namely, a concentrated power of observation, and the faculty of never becoming discouraged neither by the minutia of details nor by the length of preparation necessary to the successful execution of a preconceived plan. They have shown these two qualities in a rare degree in the organization of their late campaigns against Russia; and their success in them was due for the most part to the attention they had given during the preceding years to the preparations for that war. That they will show the same qualities in industrial pursuits is quite probable. They seem also to have remarkable talents for organization, one of the most important things demanded by modern industry where concentration is continually on the increase, and which places under the direction of the industrial chiefs large masses of workmen whose labor in order to be made efficient and remunerative must be coördinated in the most rigorous manner.

A great defect tarnishes the reputation of the industrial and commercial classes of the Japanese; it is their want of probity.

Notwithstanding, certainly, very numerous exceptions, this defect is so general that their dishonesty in business affairs has become a proverb in the extreme Orient; and many European houses which have traded directly with them have suffered heavy losses from this cause. The defect is so inveterate, that there should be created in their commercial schools courses of commercial morality. Such education, as a necessity of foreign commerce, will probably sooner or later come.

The question of labor presents still more serious difficulties than that of the education of those who direct it. The great modern industries need abundance of labor habituated to long hours of work; regular and attentive in the workshop; capable of continued effort; and sufficiently instructed to use in an intelligent manner, the implements and tools, often delicate, intrusted to them, and to understand the importance of keeping them in the good order which they require. This class of workmen Japan has barely commenced to form, and they are yet very far from reuniting the numerous qualities possessed by the workmen of western nations where the great industries flourish.

Carelessness, love of idling, want of application, are the most frequent faults found with the Japanese workman.

This working population, recently arrived from the rural districts, and drawn to the large cities by the hope of higher pay, and of an easier and, above all, more varied life, often deceived by the fallacious promises of the agents sent from province to province to engage them, is of the most worthless kind.

In general, the Japanese workman understands badly the machine placed in his hands; it is still for him a strange thing for which he continues to feel a stupid antipathy. He has not yet acquired a comprehension of its utility or of the numerous advantages to be obtained from its use.

The many deficiencies and insufficiencies of his workmen, nullify largely for the Japanese industrial the advantage of the small pay given by him relatively to the pay received by the European workman. Further, in these latter years, there has been so great an increase in the pay of labor, that an increase of its output does not seem justified, and which, under the influence of the general causes resulting from such an economic transformation and under the pressure of the labor unions, does not appear to be yet arrested. The increase of pay during the last seven years has varied between 50 and 70 per centum.

The increase of socialistic ideas, is also a menace, increasing the difficulties to be encountered by the Japanese industries, and which might signally retard their progress. The labor agitation commenced towards 1882. In 1889, was founded the syndicate of iron workers which to-day contains nearly 3000 members. In 1897, was created the Fraternal Union of Workmen, and in two years it had 6000 members. Then, in 1898, the railroad engineers and firemen formed a union, which, in 1900, engaged in a successful struggle with the companies. The syndicate movement at present very feeble and having only precarious funds at its disposal, is surely destined to follow, as in other countries, the development of the great industries.

Constrained by its economic necessities, and obliged, in order to realize its political ambitions, to become a great industrial power, Japan has no insurmountable obstacle to fear that could prevent its continued progress in the path in which it is so resolutely moving, but it will not realize its progress without halts. Of the numerous impediments, one of the most serious will be the labor question in slackening its speed. The war with Russia, by reason of the loss of men it caused, will have an analogous effect. The European industrials should, nevertheless, endeavor to maintain in the Japanese markets a more and more active competition on the part of their own national industries.

Will Japan, after the example of the Western nations, have recourse to political tariffs for hastening the development of its industries? Up to the making of the recent Japanese treaties it has not been at liberty to inaugurate a tariff protection system. These treaties have given this liberty, but they still limit its extent as regards numerous products, which, however, are the most important ones, and which have been made the objects of a special tariff. What will happen at the expiration of these treaties made to last a dozen years? Nothing in this respect can be forseen, but if, in this case, Japan should follow the example of the Western nations, there would be no reason for astonishment.

The Japanese industries in order to render the services to their country which are expected from them, must seek foreign outlets. On the doors of what markets with the European products knock in this new competition? Naturally, on the

doors of the markets of the extreme Orient, as those will be the first encountered, and the Japanese consider that these markets will always and exclusively belong to them. A Japanese writer looking at the economic future of his country, concludes as follows: "The domination of the Pacific Ocean is now the object of all the commercial nations, and China is the El Dorado of the Orient." On to China! will, therefore, be the word of command given by the politics, the manufactures, and the commerce of modern Japan.

The struggle for these markets will be difficult for the western industrials against their Japanese competitors. The latter will have the great advantages of the proximate geography, and of the similarity of race and customs. They will be more apt to divine the needs of these Asiatic populations, to stimulate them, to create new wants, and to satisfy them in respect to their habits and even to their manias. The more so, as Japan has already commenced this commercial invasion of China.

Will Japanese competition be one day found in the markets of the West? This would be a disquietude which at the present time is without cause. If the industrial development and the commercial expansion of Japan be injurious to certain European industries, they will, on the contrary, be beneficial to certain others.

During a long time yet, Japan must obtain from Europe the greater part of its machinery and large tools; and, in measure as its people, in consequence of its economic development, become richer, they will consume a greater quantity of European products of superior quality to what the Japanese industries will be capable of manufacturing.

Examined closely, the Japanese peril singularly diminishes in importance. The Japanese industries could not progress with the rapidity assumed in the attempts that are sometimes made to frighten us with it. They will encounter more than one formidable obstacle which will diminish their speed. Their chiefs will have in the education of the different classes of their workmen a laborious and extremely difficult task, and they will not be able, in the course of their growth, to avoid economic and financial crises which will cause them serious perturbations. On the other hand, the field of their competition with European industries must necessarily be a limited one.

EXPLORATION OF THE CANADIAN ROCKIES.

The work of the expedition dispatched by the Smithsonian Institution of Washington, D. C., to the Canadian Rockies and Selkirks, under the direction of Prof. W. H. Sherzer, of the Michigan State Normal School, is described in the report of the late Dr. S. P. Langley for the year ending June 30, 1905. The expedition had a successful season's work on the glaciers along the line of the Canadian Pacific Railway. A selection was made of those five glaciers which are most accessible to the student of glacial geology, and these were found to exhibit the characteristics of glaciers throughout the world. Four or five days of comfortable railway travel places an investigator in the midst of snow-fields rivalling those of Switzerland, and the ice bodies descending from these fields may be studied from modern hotels as a base, and a horse may be ridden to the feet of the glaciers studied by the expedition. So far as is known, there is in this district the most magnificent development of glaciers of the Alpine type on the American continent, and the purpose of the survey was to gather as much information as possible concerning them. Many photographs illustrating the details of glacial structure were obtained, and a full report of the expedition may be expected later.—Nature.

SMOKE SUPPRESSION IN NEW YORK.

The Anti-smoke League recently formed in New York City, is not designed, its patrons say, to prevent the burning of soft coal, but to insist on proper firing and to abolish smoke as far as possible. One firm affiliated with the league says that formerly it was able to manufacture in New York City the most delicate silk fabrics, with a very small percentage of damaged goods. For the last three years, and particularly for the last two years, it has become almost impossible to manufacture delicate shades, on account of the impregnation of the air with soft coal smoke.

THE FIRST TURBINE STEAMSHIP built in the United States was launched at the Roach Shipyard, at Chester, Pa., on Saturday, April 21. The vessel is the Governor Cobb, and is intended for the Boston-New Brunswick trade of the Eastern steamship Company of Boston. Its length is 290 feet and the width 51 feet. The motive power is Parson's turbines, which were built by the W. & A. Fletcher Company, Hoboken, N. J.

AN IMMENSE DOCK nearly half a mile in length, 1000 feet in width, and covering an area of thirty-four acres, has recently been completed at Cardiff, Wales. It is designed to accommodate the largest vessels afloat. About 1500 workmen were employed for seven years in its construction.

MARCH EXPORTS of all kinds of merchandise totaled $145,522,342, being the largest for March ever reached. The imports were valued at $133,625,066, which is the largest total for any month in the country's history.

Influence of Benjamin Franklin Abroad.

By Victor Straus-Frank.

All matters, details, however minute, pertaining to Benjamin Franklin are of the greatest import and necessity to young and old, to poor and rich, to American, European, Asiatic. Franklin's life and work are as salt to humanity. Everybody must seek at some time in life either advice or solace, often both, in the perusal and meditation of his books. All, printer, statesman, economist, farmer, in fact, every citizen.

Yet Franklin's work is not sufficiently known, popularized. His writings, most of them, should be placed in the hands of each child at the same time as the Bible. In France many a scholar learns to read out of "Bonhomme Richard." Is not Franklin one of France's greatest "citoyens?" The "demi-frère" of Voltaire.

The famous French National Library (Bibliothèque Nationale) is particularly proud of its documents and books by and concerning Benjamin Franklin. Its catalogue boasts of no less than 250 manuscripts, documents, books, referring to America's Solon.

The Franklin bi-centennary, which was celebrated last April in Paris with great pomp, has resulted in a general Franklin "book-craze." This can but benefit the nation, the world at large. But a few years ago a parcel of "Bonhomme Richard" were found in a wooden chest at Cherbourg, thrown up by the sea. The chest had been thrown overboard from the "Alabama" during the encounter with the "Kearsarge." Maybe a superstitious sailor deemed it wise to rid his sinking ship of the "Devil." At Bordeaux, valuable engravings referring to Franklin's sojourn in France have come to light. Museums, galleries, are ransacking forgotten, dusty attics in hopes of discovering Franklin relics. Franklin is *à la mode*. A century hence, his memory will shine with still more lustre.

That Franklin's reputation as a model-citizen, a great philosopher, a great statesman, a genius, is universally recognized may be gauged by the fact that many of his works have been trans-

lated into French, German, Dutch, Finnish, Swedish, Italian, Spanish, Portuguese, Turkish, Greek, Gaelic, Brittany dialect, Japanese, Chinese, etc. I have failed to trace a Russian translation.

Where Franklin's works have found their way, there Civilization has progressed.

Many of his most important works remain to be translated. The Bibliothèque Nationale of Paris counts over 250 works by the illustrious American, yet it is far from satisfied. Many important works are missing. Maybe, the actual Franklin book-hunt will result in important discoveries. It is to be sincerely hoped. Meantime the following list of authors of works referring to Benjamin Franklin to be found at the French Library is not without interest:

Jared Sparks.
John Bigelow.
P. Fievet.
A. Liégaux-Wood.
Em. Fenard.
G. Munro.
F. Lancelot.
Edouard Laboulaye.
P. A. Changeur.
Dr. Stuber.
J. G. Rosengarten.
Barbeu-Dubourg.
De La Mardelle.
C. Farine.
F. Lock.
L. Bessière (Tâbarly).
G. D'Adda.
L. François.
Stevens.
W. T. Franklin.
E. du Chatenet.
Emile Deschanel.
A. Belot.
Francis N. Thorpe.
Ed. Robins.
Ernest Choullier.
Albert H. Smyth.
A. C. Renouard.
Le Compagnon de Simon de Nantua.
Hannedouche.
G. Piegnot.
Francisco Ladislao A. D'Andrada.
O. Hubner.
D'Alibard.
Karl Berdelli.
E. Montroulez.
Bernardo Maria Calura.
Reschâd.
Belval.
Condorcet.
H. de Triquetti.
Paul de Lascaux.
Mignet.
Dr. Viger.
Alph. Levray.
James Parton.
M. Seitte.
Mme. Gustave Desmoulin.
A. Genevray.
E. Hale.
W. A. Wetzel.
John W. Jordan.
Sydney G. Fischer.

and the list is not complete.

The Franklin book-lover casts a covetous eye on the many rare editions by his countryman. Many, priceless. Their place should be in America, but, a great consolation lies in the fact that they lie in the world's greatest library.

Paris, March, 1906.

The Social and Domestic Life of Franklin.

By Agnes Irwin, LL. D.
Dean of Radcliffe College, Cambridge, Mass.

[Read by title at the stated meeting of the Institute, held Monday, January 21, on the occasion of the 200th anniversary of Franklin's birth.]

It is not easy to say anything about Benjamin Franklin, and it is almost, if not quite, impossible to say anything that has not been said before, and said over and over, for more than a hundred years. He is as well known to us as one of our own contemporaries, opportunity and material for study are both ample, and he himself is not elusive nor inaccessible; his character holds no great surprises, no perplexing depths, no subtle incongruities; he has his own secrets and keeps them very well, but they are not dark secrets of personality. He is human, and he is many-sided, but he is not complex. It is because he has so many sides and so much power, that he makes us wonder at him. "Strange that Ulysses does a thousand things so well!"

What made him what he became? What made him what he was? Where did he come from? He was in no sense a typical New Englander; the New England conscience was not in him; there was something in his temper alien to the true New-England spirit. He was born in Boston, and his mother was a Folger from Nantucket; but Nantucket is a place by itself and only geographically a part of New England, and Franklin's father was an Englishman, born, bred and married in England, who emigrated with his wife and their three children and settled in Boston about twenty-five years before Benjamin Franklin was born. It has sometimes been said that he was like the Folgers, his mother's people; he was certainly like his uncle, Thomas Franklin, who died just four years before his nephew, Benjamin, was born, on the same day of the same month. "Had he died," said William Franklin to his father, "just four years later, one might have supposed a transmigration of souls." Franklin's rise in life remains one of the endless questions of heredity, environment, opportunity. An obscure family of freeholders in an inland county in England keeps on the

even tenor of its way for more than two hundred recorded years; a member of the family emigrates to Massachusetts and works unremittingly at his humble trade of soap-boiler and tallow-chandler in order to maintain his large family of seventeen children. Of these seventeen, one, the fifteenth child and youngest son, writes his name high in the brief list of the unforgotten dead. Of the thirteen children who sat round their father's table at one time, and who all grew up and married, this youngest son was the only one who rose to distinction. The others did well enough, or stayed where they were. He must have been a clever little lad, for he learned to read so young that he "could not remember to have been ever without this acquirement," and his father destined him for the church, encouraged by his friends, who assured him that the boy would certainly become a man of letters. The father's brother, Benjamin, promised to give his namesake all his volumes of sermons. What a waste that would have been! He went to the grammar-school at the age of eight, and did very well, going up from the middle to the head of his class, from one class to another, but his father renounced his projects for the child on account of the expense of a collegiate education, and at the age of ten Benjamin Franklin left school and began to work for his father. We know very little of his early years, and all we know he has told us. He was a boy, very much like all other boys, and he lived the life of a boy on the water side, learning early to swim well and to manage boats, and he had a hankering for the sea, which may have been the desire to escape from home, so common in boys, which nearly made a privateer of Franklin's own son, or it may have been that appeal to the imagination of every coast-born New Englander, made by the wind from the sea. "A boy's will is the wind's will and the thoughts of youth are long, long thoughts." He was "generally a leader among the boys, and sometimes led them into scrapes," as in the case of the wharf, built with other people's property; and in a boat or canoe, he was "commonly allowed to govern, especially in any case of difficulty." His dislike for his father's trade, his passionate love of reading, his differences with his brother, the flight from home, the new life in a strange land—we know it all by heart, for he has told us.

The Autobiography is the one great source of information

about Franklin during the early years of his life. There are few letters, fewer traditions, no legends. His tie with his own family was never very strong, and he writes to his sister Davenport (about the year 1727), "Your kind and affectionate letter was extremely agreeable to me, and the more so, because I had not for two years before received a line from any relation, my father and mother only excepted. * * I should be mighty glad of a line from [Sister Mecom] and from Sister Holmes, who need be under no apprehensions of not writing polite enough to such an unpolite reader as I am. I think if politeness is necessary to make letters between brothers and sisters agreeable, there must be very little love among them. * * * Dear sister, I love you tenderly." Of this same sister Davenport, he writes to sister Mecom (19th June, 1730), "Yours of May 26th I received, with the melancholy news of the death of sister Davenport, a loss, without doubt, regretted by all that knew her, for she was a good woman. Her friends ought, however, to be comforted that they have enjoyed her so long, and that she has passed through the world happily, having never had any extraordinary misfortune or notable affliction, and that she is now secure in rest, in the place provided for the virtuous." He hears "the affecting news of his dear good mother's death" with the like decent composure, and, if he needs consolation, he finds it in the thought that "She has lived a good life, as well as a long one, and is happy." His letters to his mother are filial and kindly, with an occasional evidence of affectionate care for her comfort—for example, "the moidore enclosed towards chaise hire, that you may ride warm to meetings this winter;" and he takes pains to tell her about her grandchildren just the kind of news a grandmother wishes to hear. (16 Oct, 1749) "Your granddaughter is the greatest lover of her book and school of any child I ever knew, and is very dutiful to her mistress as well as to us." (Date uncertain) "As to your grandchildren, Will is now nineteen years of age, a tall, proper youth, and much of a beau. He acquired a habit of idleness on the Expedition, but begins of late to apply himself to business, and I hope will become an industrious man. * * * Sally grows a fine girl, and is extremely industrious with her needle, and delights in her work. She is of

a most affectionate temper, and perfectly dutiful and obliging to her parents, and to all. Perhaps I flatter myself too much, but I have hopes that she will prove an ingenious, sensible, notable and worthy woman, like her Aunt Jenny. She now goes to dancing school." To his sister Jenny, indeed, he was truly a "loving brother." When he is a young man of twenty, he writes to her, "I always judged by your behaviour when a child, that you would make a good, agreeable woman, and you know you were ever my peculiar favorite.* * * I hear you are grown a celebrated beauty." When he is nearly forty years old, and has made his way in a strange land, she seems to feel "some uneasiness" about his attendance at worship, and his reliance on the efficacy of good works; he takes her admonition very kindly and is far from being offended with her for it. A year or two later, she entrusts her son, Benjamin, to his care, and his letters about Benny Mecom show a perfect comprehension of "the nature of boys" and of the ways of parents. "I have not shown any backwardness to assist Benny," he says to his sister (May, 1757), and indeed he had done for his nephew everything that he asked, except "embrace his quarrels and gratify his resentments." That there were family quarrels and that Franklin took no part in them, is clear: "I think our family were always subject to being a little miffy," he says in a letter written during the last year of his long life, and he tells a story of his kinsmen in Nantucket, which goes to show that if they kept away from him in his youth, they were quite as ready to keep away in his old age.

"By the way, is our relationship in Nantucket quite worn out? I have met with none from thence of late years, who were disposed to be acquainted with me, except Captain Timothy Folger. They are wonderfully shy. But I admire their honest plainness of speech. About a year ago I invited two of them to dine with me. Their answer was, they would, if they could not do better. I suppose they did better, for I never saw them afterwards, and so had no opportunity of showing my miff, if I had one."

His domestic life, when he had a home of his own, a wife and children, was the life of a busy tradesman, with many interests, some small, some great and growing greater. His letters to his wife are affectionate, but not lover-like; they show how implicitly he trusted her, and how faithfully she looked after his

affairs for him; they show, too, how little she shared in his intellectual life, and how content he was that it should be so. In 1757, in a letter written from New York on the eve of his sailing for England, he writes to her to send him "the Indian Sealskin Hussiff with all the things that were in it. It will be an acceptable present to a Gimcrack great Man in London, that is my Friend." And he asks for the "two or three little Pieces on the Game of Chess, among my Books on the Shelves. One in French bound in Leather, 8vo. If you can find them yourself, send them. But do not set anybody else to look for them. You may know the French one by the work Echecs in the Titlepage." From these descriptions we infer that she had very little curiosity and no French. The letters from England are longer and fuller, and leave nothing to be desired. He sends her "a crimson satin cloak, the newest fashion." Did she go to Christ Church in a crimson cloak, and her daughter Sally with her, in the scarlet feather, muff and tippet, that Billy Franklin sent her in the same invoice? Mrs. Franklin went to church, and her husband writes from London: "I had ordered two large print Common Prayer Books to be bound on purpose for you and Goodey Smith; and that the largeness of the print may not make them too bulky, the Christenings, Matrimonies, and everything else that you and she have not immediate and constant occasion for, are to be omitted. So you will both of you be reprieved from the use of spectacles in Church a little longer." At one time he sends a large case and a small box, containing carpets, gowns, silver, china—"to show the difference of workmanship, something from all the China Works in England." For Sally there were two sets of books, The World and the Connoisseur. Sally was very dear to him. He had, in 1757, a long intermitting fever, in which his landlady, Mrs. Stevenson, was very obliging and very diligent, but he writes to his wife, "I have a thousand times wished you with me, and my little Sally with her ready Hands and Feet to do, and go, and come, and get what I wanted." "My dear good Sally whose little hands you say eased your headache," he says in another letter. He hopes that "Sally applies herself closely to her French and Musick and that she continues to love going to church." "Sally's last letter to her brother is the best wrote

that of late I have seen of hers. I only wish she was a little more careful of her spelling."

These five years in England must have been the happiest of Franklin's happy life. He says on his return, "I have had a most agreeable time of it in Europe. I have, in company with my son, been in most parts of England, Scotland, Flanders and Holland; and generally have enjoyed a good share of health." He was employed in business of importance; he was well off for his station; he was not unduly homesick, except when he was ill, and even then he was frank enough to write, "The agreeable conversation I meet with among men of learning and the notice taken of me by persons of distinction, are the principal things that soothe me for the present, under this painful absence from my family and friends." For now Franklin was famous. He had made his discovery; he had received the Copley Medal and was a Fellow of the Royal Society; when he went to the Commencement at Cambridge, his "vanity was not a little gratified by the particular regard shown [him] by the chancellor and vice-chancellor of the University, and the heads of colleges."

When he was in France with Sir John Pringle, in 1767, he went to court, and was presented to the King (Louis XV), who did Franklin the honor of taking some notice of him and spoke "very graciously and very cheerfully." In his account of the interview, Franklin makes no reference to the communication from the King to the Royal Society in which the King sends his express thanks to Mr. Franklin of Pennsylvania. He had suddenly become famous, but his head was not turned, though he showed his pleasure in his success, and he made friends everywhere. No wonder that he looked back on the poverty and obscurity in which he was born and bred, and counted himself a happy man. It was the late afternoon of his long day, and the twenty years that followed his return from England, in 1762, were to see the high-water mark of his public career; but his "vogue" had already begun, and the taking and making his likeness, which raged like an epidemic, was just beginning. The political situation made the sky very dark, and Franklin had more than his share of the public burden. His son William espoused the English side, and was estranged from his father; Mrs. Franklin died, and his little Sally married during his ab-

sence and not wholly to his mind; old age crept on apace and brought with it infirmities; but he kept on, vigorous, alert, undaunted, cheerful, full of interest, perfectly himself to the end. "The time of his life" was the time in Paris, the memory of which has lately been freshened by John Hay's article in the Century Magazine for January, 1906. He became the fashion, the idol of the populace and the darling of the court; his likeness was taken over and over again, in clay, in marble, in bronze, in oil, in pastel, in prints "(of which copies upon copies are sold everywhere)," until his face was "as well known as that of the moon;" "perhaps few strangers in France have had the good fortune to be so universally popular;" the society he gathered round him in his own house at Passy was absolutely to his liking; it was "the best in France—the true élite," at the time before the French Revolution of which Wordsworth wrote,

"Bliss was it in those days to be alive,"

a society of "princes all by intellect and many of them by birth." To be sure it did not satisfy Mr. Ralph Izard, who asked one day, "Why couldn't we have some of the gentlemen of France?" but Mr. Izard, although "untinctured with asperity upon every subject but one," was like the Nantucket cousins, and thought he could do better than dine with Dr. Franklin.

In this society Franklin played his part to perfection, thanks to "the amenity of wit and good humor" for which even Andrew Graydon gives him credit, and perhaps, thanks to the extreme wariness of his character, which was not more congenial to the feelings of Graydon than to those of Mr. Izard. He achieved the end for which he had been sent, and came back in 1785 to take his share in framing the Constitution. His two grandsons came home with him, Temple, who was his secretary, and his grandson Bache, his daughter's oldest son. The boy had gone abroad with him at the age of "half past six," to use his own phrase after his English had suffered for want of use, during four years at school in Geneva. He was "docile and of gentle manners, ready to receive and follow good advice" and his grandfather "loved him very much." He was bred to the trade of a printer while he was in France, Didot, to please Dr. Franklin, teaching the young Bache at the same

time with his own son Firmin. There is extant, in the possession of one of Benjamin's grandchildren, a diary kept by the boy for his far-away mother. I have not seen it for many years, but I remember it as a perfect example of a boy's diary, irregularly kept, incomplete, wholly personal, and full of such obvious truths as "I went to M. Didot's to take a lesson. M. Didot went out, and left us at work. Firmin and I played."

Franklin had written from France, on his way to embark for America:

"I have continued to work till late in the day; 'tis time I should go home, and go to bed." But there was public work yet to do; and he did it until the end was near. He had public business enough to preserve him "from ennui, and private amusement besides in conversation, books, the garden, and *cribbage*." His daughter lived with him and was the comfort of his declining years. His grandchildren were constantly with him, and he took "great pleasure in their cheerful prattle." The younger ones are said to have been spoilt and unruly, and on one occasion, he was irritated to harshness by one of the little girls, but they stood in no fear of him, and he thought them promising. One must think, with Mrs. Logan (Deborah Norris) that "Dr. Franklin must have sensibly felt the difference between the éclat which he enjoyed at the Court of France, and the reception which he met with upon his final return to his native country. The mass of the population of Pennsylvania was, as it has been ever since (and may I not say ever was?) decidedly democratic; but there was a contrary spirit then dominant and thinly diffused over the surface of society which rejected the philosopher because they thought he was too much of that popular stamp. The first Constitution of our State after the Revolution, which was his work, was disliked; and I well remember the remark of a fool, though a fashionable party-man at that time, that it was by no means "fashionable" to visit Dr. Franklin. * * * Foreigners of the first distinction thought themselves happy in obtaining such a privilege, and a few of his old tried friends yet remained to cheer the evening of his eventful life."

Truly an eventful life; truly a remarkable person. "But so it sometimes is , a True Genius will not content itself without entering more or less into almost everything, and mastering many things more, in spite of Fate itself."

(Stated Meeting, held Wednesday, March 21, 1906.)

Improvements in the Diffraction Process of Color Photography.

By Herbert E. Ives.

The diffraction process of color photography, invented by Prof. R. W. Wood, of Johns Hopkins University, in 1899, is an application of the well-known three-color method of reproducing colors by photography. This method depends primarily upon the observations of Young, Helmholz and Clerk Maxwell, that all the colors of the solar spectrum may be counterfeited to the eye by mixtures of three narrow bands of color from the spectrum, these colors are *red*, near the Fraunhofer line C; *green*, near E, and *blue*, near F. For instance, red and green mix to give the eye a sensation of yellow indistinguishable from the true yellow of the spectrum; red and blue mix to give purple; and the three colors acting together produce a white whose difference from ordinary white light can be detected only by analysis with a spectroscope. What applies to spectrum colors applies equally well to the varied hues of nature. The coloring of such an object as a basket of fruit can also be duplicated to the eye by mixtures of the three primary colors. The tint of an apple, by a large proportion of red, less of green and blue; of a lemon, by nearly equal parts of red and green; of grapes, by a large proportion of blue.

The three-color process can be reduced to two problems; first, the production of three photographic negatives, each of which shall be an exact record of the amount of one of the primary colors requisite to mix with the others and counterfeit to the eye the color of the object photographed; second, some means of furnishing each record with its appropriate color and combining it with the others.

The solution of the first problem has been arrived at from experimental quantitative determinations of the mixing proportions of the primaries to produce the other colors. From these determinations three-color screens can be prepared,

which, when used with suitable photographic plates, will yield three (black and white) negatives, each having the desired destitution of light and shade to form a record of one primary color. The negatives thus obtained are the basis of all three-color reproduction methods.

Numerous means have been suggested and tried for combining the three-color records with their corresponding colors. They may be placed in a triple lantern, each illuminated with its proper colored light and projected, superposed, upon a screen. The superposition may be effected by a system of mirrors, as in the Kromskop; by the use of three thin transparent films properly colored; by triple printing on paper, after the manner of much of the present-day magazine illustration.

A process which must be noted somewhat in detail because of its direct bearing on the recent development in diffraction color photography is the so-called Joly process*. Combination of the colors is effected in this by breaking up the three-color records into narrow lines, arranged in succession, a line of the red record, a line of the green, a line of the blue, and so on repeating across the picture. This triple record, whose lines should be close enough together to be indistinguishable by the eye, is mounted over a triple ruled color-screen,—a line of red pigment, a line of green, a line of blue, similarly spaced to the lines of the picture. The result, if the lines are fine enough—a condition never yet attained in the actual working of the process,—is that the eye blends the lines to form a structureless color picture in the form of a transparency.

The diffraction process, which is the subject of this paper, departs widely from the other methods. Its distinguishing feature is that for the production of the primary colors to view the records use is made of the diffraction grating, that is, of a transparent polished surface, usually of glass, ruled with fine parallel straight lines, several thousand to the inch. It is the property of a diffraction grating that if a bright line or point of light is viewed through it, not only will the light source be seen, but spread out to either side will be a series of spectra, those nearest the source being called spectra of the first order, the next, of the second order, etc. If the number of lines to the

* First published, as a matter of fact, by Louis Ducos du Hauron in 1869.

inch on the grating be increased the spectra are thrown farther from the central image, and vice versa.

The power of a grating to produce color is taken advantage of in the following way: Suppose we have a convex lens forming an image on a screen of a bright source of light, such as a gas flame. If the eye is placed where the image is formed the lens is seen uniformly and brilliantly illuminated. Suppose now a diffraction grating is placed over the lens. In addition to the image formed as before there will be produced a series of spectra. If the eye is placed in one of these the lens will, as before, appear illuminated, not, however, by light of the color of the source, but by the color of light striking the eye.

If now we can make one of our color records in the form of a diffraction grating of varying strength to correspond to the desired differences in the amount of the primary color, and

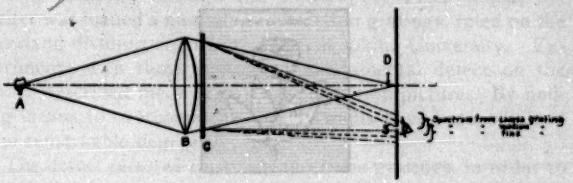


Fig. 1

place it over a lens, points can be found in the lateral spectra in which the lens (and the grating in coincidence with it) will appear as a colored picture. Further, since, as we have seen above, the distance of the spectra from the central image depends upon the fineness of the grating spacing, it is a simple matter to choose three gratings, one of which will send red to a chosen point, the second green, the third blue. Hence if we can make the three primary color records in the form of three diffraction gratings of three properly chosen spacings, each may be seen in its proper color by placing the eye in one of the diffraction spectra formed as above described.

In Fig. 1 we have represented the conditions for viewing diffraction color pictures. A is a source of light, B a convex lens, in front of which are three gratings G. On the screen D fall the central image I, and three spectra (only the first order spectra on one side are represented) so placed that the red of one,

the blue of another, and the green of the third are superposed on the slit S, at which the eye is placed.

In Fig. 2 we have represented diagramatically a diffraction color picture of a red flower with green leaves on a blue ground. The coarse spacing of the lines in the flower represents a grating to send red light to the eye, say 2400 lines to the inch, the medium spacing of the leaf one to send green to the eye, say 3000 lines to the inch, the fine spacing of the background one to send blue, say 3600 lines to the inch. Mixed colors would be given by two or three gratings acting together.

To produce such gratings by photographic means the bichromated gelatine process, which lends itself well to the copying of minute structures, was used. In contact with a surface sensitized in this way was placed a glass grating; the image of the corresponding color record was then projected upon the surface

Fig. 2

for a sufficient time to give a full exposure. The grating was removed, another substituted and exposed under its corresponding color record, and so with the third. In this way all three grating pictures were printed, one on top of another,* forming a picture which by diffused light was transparent and quite invisible, showing its color only when viewed with the proper combination of lens and bright source of light. From the pictures made in this way copies could be made by simple contact printing on bichromated gelatine. Since a direct copy of a grating is still a grating, *i. e.*, a series of lines, the process is a positive one and copies are not reversed in light and shade as in making copies of ordinary photographs.

It is obvious that quite apart from its scientific interest the

*In practice it was found impossible to get three impressions on one gelatine surface and so two were made on one surface and the third on another, the two surfaces being afterwards placed in contact.

diffraction process promises very real advantages. For instance, the colors used are beyond question pure spectrum colors, and so there is no need to depend on dyes or colored glasses; also the ease and cheapness with which copies can be made places it in a class by itself among three-color processes. So perfect indeed did the process seem theoretically when first published that there was every reason to expect results fully comparable with the best of other methods.

This early promise was not fulfilled. A few pictures were obtained, interesting as scientific curiosities only. No dependdence could be placed in the results; some colors reproduced well, others did not; occasionally a good picture would be made, but the same procedure applied to another subject brought no success. Six years after its publication the process had made no progress and seemed fated to rank as a failure.

Last summer, through the courtesy of Prof. Wood, the writer was loaned a number of diffraction gratings, ruled on the Rowland dividing engines at Johns Hopkins University. Experiments with these revealed a fundamental defect on the above-described mode of making diffraction pictures. By finding means to overcome this defect results have been obtained of a remarkable degree of perfection.

The defect referred to is that the three gratings, in order to get their joint effect, were *superposed*, being, as we have seen, printed one on the other. In so doing the assumption was made that the effect of superposing gratings was to add their separate effects. As a matter of fact, additional, disturbing effects are introduced, partly due to the inability of the gelatine surface to take several grating impressions without mutual blotting out, and partly—chiefly, in fact—to the forming of a new compound grating. That is, if two gratings of different spacings are superposed, the two spacing periodically get in and out of step with each other, and this new periodic structure forms itself a diffraction grating. The new grating then forms its own series of spectra, which subtract light from the original ones. Therefore when the two gratings are superposed, the eye, instead of receiving a double quantity of light receives much less than the double quantity. Even more serious than this loss of light is the fact that the new spectra due to the two gratings together frequently fall in such a position as

to introduce *false colors*. This is well illustrated by taking two gratings of different spacing and placing them on one another at right angles. Two sets of spectra will be formed, one by each grating, and parallel to it, and, in addition, a number of diagonally disposed spectra. As the gratings are turned into the same straight line all the spectra turn, and the additional diagonally-placed spectra take up positions between the spectra formed by the original gratings. Consequently, while the eye may receive red from one grating and blue from another, one of the spectra due to the two together may send some other color, such as green. This case actually occurred frequently, a pink rose reproducing as green, and red and blue color discs superposing to give green instead of purple.

These observations made clear the necessity for some method of obtaining the effects of the three gratings other than by superposition. It was at once seen that this could be accomplished by a procedure similar to the Joly process, namely, by having the grating elements in narrow juxtaposed strips. Some experiments had already been made by Prof. Wood with Joly pictures, not, however, with the specific purpose above mentioned, but rather to illustrate to possibility of making such pictures with very much finer color lines than it is possible to do by ruling alternating colored pigment lines for the observing screen. The mode of procedure involved laboriously ruling a special grating consisting of several lines of one spacing, followed by several of another, and then several of the third, repeating all the way across the plate. The width of each strip of lines was made to correspond to the width of an element of the Joly picture. From this grating a print was made on the special-line picture, which had been previously flowed with gelatine. This in turn was used to print gelatine copies.

A practical disadvantage of this plan, aside from the use of the special grating, is that one is restricted to the use of original Joly pictures of a certain definite spacing of line, determined by the limitations of the process employed in their production. A much more serious defect arises, however, in this way: The "Joly lines" if made, as they should be made, several hundred to the inch, themselves form a diffraction grating, which, as it is parallel to the three principal gratings, forms spectra

superposed on those depended on to reproduce the colors of the object. This is quite as serious a defect as that arising from superposed gratings, and is sufficient to condemn the procedure.

From a consideration of these various difficulties it followed that some means of breaking the picture up into lines was imperative, and that that means should not involve the use of a special grating, nor of special Joly original pictures, difficult to obtain, and, most important of all, the narrow color strips or Joly lines must be arranged in some way so as not to give disturbing grating effects.

All of these ends were achieved by the following procedure:

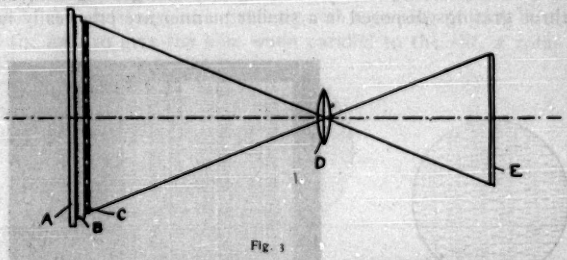


Fig. 3

In Fig. 3, which represents the method of making the improved diffraction pictures, A is the bichromated gelatine plate, rigidly fixed in position; B is a glass diffraction grating; C is a line screen, ruled with at least two hundred lines to the inch, with the opaque lines twice the width of the transparent;* D a lens, and E a positive color-record to be copied. The latter is an ordinary three-color positive containing no lines or structure,† and the grating is an ordinary continuously-ruled one. With say the red record at E and the corresponding grating at B, an exposure is made, resulting in a series of narrow strips. A second positive is then placed at E, the corresponding grating at B and the ruling C moved the midth of a transparent portion. A second exposure is then made, the opaque

* The opaque line screens were ruled by Mr. Max Levy, to whom, for his interest and generous assistance, the writer is greatly indebted.

† Positives from negatives made for the Kromskop were used.

lines shielding the previously exposed surface, and a similar treatment given to the third positive. There results finally a picture made up of alternating strips of three different gratings.

To eliminate the grating effects of the narrow strips of gratings considered as lines, the device is used of making the strips (Joly lines) run at right angles to the diffraction grating lines, so that the spectra produced by them are thrown off in another direction and do not enter the eye. Although the device is simple it is of extreme importance, and its adoption is rendered possible only by the plan described for making the pictures. The difficulties in the way of ruling a special grating with the three gratings disposed in a similar manner are practically in-

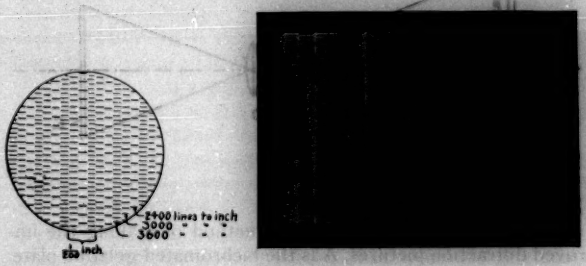


Fig. 4

superable. It is obvious that the strips of grating can be made as narrow as desired, easily narrow enough to be indistinguishable as such by the eye.

Fig. 4 gives an idea of the appearance of the finished picture under the microscope. The short, fine lines are the diffraction grating lines furnishing the three primary colors; 2400 to the inch for the red, 3000 for the green, and 3600 for the blue. The broad strips at right angles to the grating lines constitute the "Joly lines," of which there should be at least 200 groups of three to the inch.

When viewed with a lens and bright source of light the pictures made in this way are entirely free from the formerly-obtained defects. The colors are pure and brilliant, and, unlike ordinary Joly pictures, the color lines are too fine to be visible.

The results indeed approach those obtained with the Kromskop.

As a further modification of the original method the writer has found it possible to dispense with three gratings and obtain the colors with a single grating spacing properly used. To do this the source of light must be a rather long slit. Viewed through a grating the slit of course gives long spectra parallel to its length. If now the grating be rotated about, the perpendicular dropped from it to the slit, the spectra move in toward the slit. [The accompanying shift parallel to the length of the slit is compensated for by the slit being long.] So, by suitable rotation any desired spectrum color may be obtained at a chosen point. Starting with a grating of 3600 lines to the inch to give the blue when parallel to the slit, a rotation of about 21½ degrees will give the green, of 42 degrees the red. In the absence of suitable dividing engines to rule three properly-proportioned gratings this affords an exact and easy method of securing the three colors. It has the fourth advantage, that in printing copies such difficulties as securing perfect printing contact will affect all three colors alike, which is not the case with gratings of different degrees of fineness.

Fig. 5

Fig. 5 shows a portion of a picture made in this way with one grating spacing.*

*After working out this idea the writer learned that some years ago Mr. Thorp, of Manchester, suggested the use of a single grating spacing to secure all three colors. Mr. Thorp's plan, however, was to use three sources of light and merely rotate the gratings until they "found" the source and each cleared the source belonging to the other two. He found a rotation of ten degrees convenient. As far as the writer knows this is the first publication of a plan to secure any desired color by rotation through a definite angle to be calculated from the wave length.

With these improvements probably the last word has been said on the diffraction pictures themselves. A very important improvement in the means for observing them, due to the writer's father, Mr. Frederic E. Ives, must be described.

The lens and bright light used by Prof. Wood do not form at all a conveinent arrangement, nor is it desirable to use artificial light. A convenient apparatus, easily set up, not liable to get out of order, and suitable for daylight use became desirable as soon as the pictures are perfected. The instrument about to be described was devised a few hours after the first pictures were obtained, and admirably fulfills its purpose. The greatest difficulty attending the use of daylight is that of getting sufficient light,—the illumination of the sky, toward which an instrument would naturally be pointed, is far from intense enough. This will be appreciated when it is remembered that only a very small portion of the original light is diffracted, perhaps ten per cent. at most. This difficulty has been overcome in a novel manner. Instead of depending on a single slit, as the narrow source of light, a series of slits is used, each furnishing one spectrum. In this way, with four slits, two first order and two second order spectra are utilized, yielding probably three times the light obtainable from a single slit.

Fig. 6 gives the instrument in section. A, B, C, D are the four slits; M a mirror; L_1 and L_2 lenses; P the diffraction picture; and S the slit through which the picture is observed. The lenses of course form an image of each slit at A^1, B^1, C^1, D^1; from each of these images, however, a certain amount of light is diffracted by the pictureP; from B and C first order spectra fall on S, from A and D, second order. The use of second as well as first order spectra is a distinct advantage in that, as gratings never give a perfectly uniform distribution of light and color, certain desirable qualities of the picture are found in one order and not in the other, while if both orders are used the resultant evening up of qualities produces particularly satisfactory results.

By disposing the grating lines in a horizontal direction and using horizontal slits as sources the pictures may be viewed by both eyes, a desirable condition for convenience and comfort.

As an instrument the "Diffraction Chromoscope" is simplicity itself. It is, in fact, used much as the old stereoscope.

There are no adjustments; to use, it is merely placed before a window or Welsbach light and the pictures dropped to place. On looking into the eye slit before the introduction of the picture nothing is seen, the inside being perfectly black. The pictures themselves are transparent, colorless, and appear as plain pieces of glass under ordinary conditions of illumination. On placing them in the instrument the colors immediately flash out, a transformation which seems almost magical, affording a scientific demonstration of rare beauty.

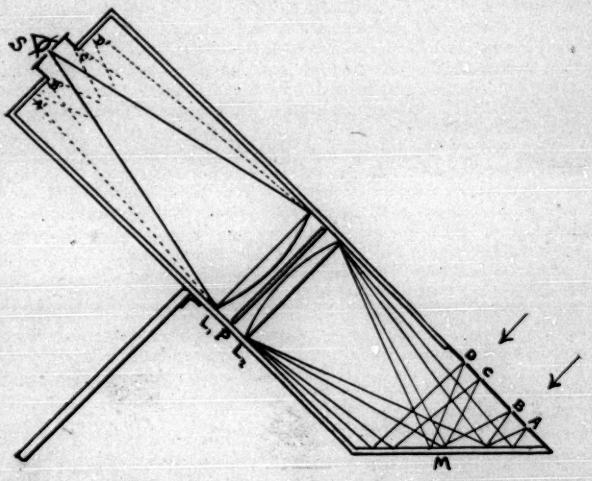


Fig. 6

Aside from the obvious use of the apparatus for scientific purposes it is expected that its simplicity and the perfection of the results will ultimately lead to many important uses. Now that the long standing obstacles in the way of success have been removed the process should develop rapidly. Such further steps as application to lantern projection and means for making the pictures directly in the camera are under consideration.

IMPROVED METHOD OF FIRE PROTECTION.

At the recent annual meeting of the National Fire Protection Association, held in Chicago, the following resolutions were adopted:

WHEREAS, The National Fire Protection Association was formed ten years ago "to promote the science and improve the methods of fire protection; to obtain and circulate information on this subject and to secure the coöperation of its members in establishing proper safeguards against loss of life and property by fire," and,

WHEREAS, In spite of all efforts up to the present time the terrible fire waste of this country has continued uninterruptedly, involving a loss per capita several times greater than in other countries, and,

WHEREAS, Public protection has not kept pace with the growth and increase of valuation in congested centers, and as the business conditions and prosperity of the country are liable to interruption if this increasing loss cannot be checked,

Be it Resolved, By the National Fire Protection Association in convention assembled, that an urgent appeal be and is hereby made to all interested to coöperate in bringing about better conditions by adopting improved methods of construction, by safeguarding hazards of occupancy and by introducing automatic sprinklers and other private protection with private water supplies quite in addition to the Public Fire Service, and,

Be it further Resolved, That we recommend that municipalities pass ordinances involving the adoption of an approved Building Code along the lines of the building recommended by the National Board of Fire Underwriters, and requiring the introduction of Automatic Sprinklers with private water supplies, in buildings of special occupancy and in so-called congested districts, to the end that the danger of sweeping conflagrations may be largely eliminated.

May 23, 1906.

A HUGE TOWAGE UNDERTAKING.

The immense floating dry dock *Dewey*, which has been sent out to the Philippines by the United States Government, has recently passed through the Suez Canal in tow of the 7,000-ton supply ship *Glacier*, assisted by two colliers, one of 5,000 and the other of 6,000 tons displacement. A powerful ocean-going tug, the *Potomack*, is standing by on the voyage as supplementary relief. Before the dry dock quitted America it was tested by placing the battleship *Iowa* and the cruiser *Colorado* in it; this test and others of a different characer were carried out successfully. The total distance to be covered is close upon 12,000 miles, and it was estimated that a rate of 100 miles per day would be kept up.

The Plateau Country of the Southwest and La Mesa Encantada (the Enchanted Mesa).

By Prof. Oscar C. S. Carter.

There are many wonders and strange corners in the great Southwest. Arizona, New Mexico and the Southwest generally are fascinating, not only to the geologist, but the archæologist and ethnologist as well. There is an air of mystery and weirdness which anyone, even the least imaginative, is bound to feel. The cowboy in his free life is also under the spell. The average tourist is in a hurry to get to California, the land of flowers, and he speeds rapidly through the arid tract, much of which looks uninviting from the car window. It is the land of cliff dwellings, as well as the ruins of villages in the open country where one sees strange drawings and hieroglyphics on the rocks of bright red sandstone. It is the land of isolated volcanic peaks, enormous lava flows, painted deserts, high mesas and, last but not least, the greatest and grandest scenic wonder of the world, the grand cañon of the Colorado, in which all other cañons would be lost and whose side cañons even, vie with the Yellowstone cañon in depth. There dwell the Hopis and Acomas who build stone houses on bare rocky mesas several hundred feet above the desert, where not a blade of grass grows, and they make the mesas their permanent abode. These peaceful Pueblo Indians till the soil of the valleys under this harsh and trying environment and deficient rainfall. This southwestern region is also the home of their fiercer, restless and migratory brothers, the Navajos and Apaches. The cliff dwellings and other ruins are scattered over the greater part of the Southwest, and the Bureau of Ethnology under the Government has done excellent work in describing many of them as well as the Indian life of the present and past; but the West is a country of magnificent distances, and many places have never been visited. Many dwellings are in an excellent state of preservation, even the mud mortar being preserved. This is especially the case when they are in

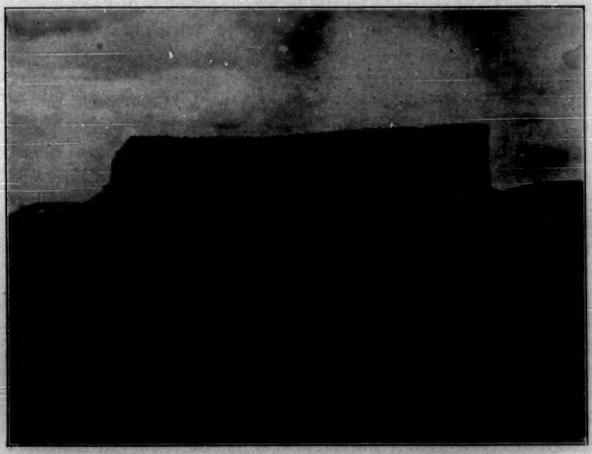
a sheltered spot, such as under overhanging cliffs where they are protected from the elements. Slowness of decay is characteristic of the arid region, where the air is dry, the altitude high, and the rainfall but eight to twelve inches a year. Eroson in that country produces weird and fantastic effects which we do not see in the East. There are places in Arizona and New Mexico where erosion has carved out some curious and bizarre forms from the sandstones. One of these localities is the valley in which is situated the Enchanted Mesa, in New Mexico. This far-famed mesa is in the southeastern part of the plateau region, very near the edge or boundary line. The plateau region or province contains so many natural and ethnological wonders that a description of it is necessary. It is sometimes called the Colorado plateau, because the Colorado River has cut its way through it. It is an elevated plateau from 4000 to 8000 feet above tide. It includes the southern half of Utah, the northern half of Arizona, Southeastern Colorado and Northwestern New Mexico, embracing an area of over 200,000 square miles. The Plateau Region begins in Utah, just south of the Uintah Mts. This interesting range of mountains is the only one in the United States having an east and west trend; they extend from the Wasatch Mountains to the Rockies. They are unlike other mountains. They have no peaks, just one enormous dome of sedimentary strata (sandstone), and not a piece of igneous rock found in the entire range. The Wasatch Mountains form the western boundary of the plateau region in Utah for a distance of 100 miles. These mountains have a north and south trend. In Arizona there is a low desert area in the south and the high plateau region in the north, a high wall or escarpment separates them. This escarpment enters Arizona from Utah on the north and trends from northwest to southeact. It is really the southern border or end of the Colorado plateau, which extends from Utah southward, often as a series of gigantic steps. The plateau country is the land of the mesa and cañon. The green of the upland and meadow so familiar in the East is wanting here. Instead, we find long lines of plateaus and mesas with steep precipitous slopes, mesas of great length and altitude. The name plateau might signify a level area easy of access and travel, but on the contrary in many parts it is extremely rugged and traveling is

difficult. These glaring red and yellow tablelands can only be crossed when you know the country. The strata of the plateau consist of layers of sandstone shale and limestone of Palæozoic and Mesozoic ages, and lie nearly horizontal with but a slight dip. Great fractures divide the country in the northwest part of the region into blocks of sandstone from ten to twenty miles wide. The region is full of volcanoes and enormous lava flows. A traveler might pitch his tent every night on a lava flow. The San Francisco peaks near Flagstaff, Arizona, are volcanoes nearly 13,000 feet high, snow-capped in August. At Ash Fork there is a bed of volcanic ash over 100 feet thick. These inland volcanoes, 400 or 500 miles from the ocean, are striking exceptions to the rule, that volcanoes are found along the shores of islands and continents. These flows are recent in a geological sense, and took place in Tertiary times. But some of the lavas are so fresh and little weathered that they are undoubtedly very recent and were perhaps seen by the Indians. At one place the lava entered the dwelling of a so-called Cliff Dweller, and it is a well known fact that these people were merely the ancestors of the present Pueblo Indians, and are not so ancient as is generally supposed. They made their homes often on the cliffs and mesas as do their descendants the Hopis and Acomas to-day. It is a well-known fact that the rainfall is slight on the plateau region, not sufficient for agriculture without irrigation, and irrigation is impossible there in some places on account of the enormous depths of the cañons. It is simply impossible to get water from their great depths to the rim. In some places, particularly near rivers like the Rio Puerco, artesian wells reach an underground supply. This is probably a young river. It has not a wide open valley which is a sign of age. It has not even cut a deep cañon as yet, but farther to the north, between the Santa Fé Railroad and the Grand cañon, artesian wells are out of the question, as the underground strata of limestone, sandstone and shale seem to be practically dry in many places. Part of the plateau along the western edge in Arizona, particularly the country that surrounds the San Francisco peaks and Mogollon Mountains, and the Cocanini plateau farther north near the Grand cañon, supports enormous forests of stately yellow pine (*pinus ponderosa*) which are far apart enough for a stage to drive through the

forest. There is no undergrowth, but during the rainy season, in July, they are carpeted with wild flowers, such as the Indian paintbrush, pink and violet lupins, yellow primroses, iris, yellow marigolds, butter cups and wild roses, and in the ravines grow the pueriposa lily. This seems a brilliant patch of foliage for an arid region, but it must be remembered that the elevation of the plateau here (7000 to 8000 feet) is sufficient for a greater rainfall and the flowers spring up during the rainy season. It seems an apparent contradiction, but a journey of ten miles to the east of these pine forests, found at the base of the San Francisco peaks, brings us to the depressed area known as the Painted Desert, a veritable Sahara, which no one would think of crossing unless well supplied with water. Enough has been said to make the reader acquainted with the physiography and climate of the country in which the Enchanted Mesa is located. This is necessary because the traditions, habits, and modes of life of the Indians near by are profoundly influenced by their environment. Powell states (in 19th Annual Report of Bureau of Ethnology) "that a harsh environment begets profound faith. This is illustrated by the history of many cults. The Pueblo region was a gathering ground of many faiths; thirst and famine were ever threatening. Ceremonies with growth of corn and for rain and the reverence of beast gods are common." The start for the Enchanted Mesa is made from Laguna, a Pueblo Indian village, situated along the Santa Fé Railroad in New Mexico, sixty-six miles west of Albuquerque. We arrived at Laguna about midnight and were naturally anxious about accommodations.

The operator told us to walk across the track and we would find a half-breed asleep on the porch. It is the only frame house there, he said, all the others are adobe. We followed his directions and obtained first-rate accommodations with Mr. Marmon, who had lived among them for more than twenty years and married a Pueblo woman. They had an interesting family of boys and girls, some of whom were educated at Carlisle. Laguna is not a very ancient Pueblo. It was founded, according to Lummis, about 1699. Although Mr. George Dorsey, the well-known authority of the Bureau of Ethnology, says (Indians of the Southwest) that it was founded at the close of the Eighteenth Century by deserters from Acoma,

On the Road to Enchanted Mesa and Acoma



Enchanted Mesa—Dense Growth of Gramma In Foreground

Zuni and Sia. There are several villages in all that constitute Laguna, but the summer villages are not visible from the station. There is no doubt at all that the Indians were disturbed by the building of the railroad. Many families left and established summer houses and ranches and finally made them their permanent abode. Mrs. Marmon told me that many families had left. The population of the villages is 1100. They make excellent pottery, which they sell to tourists when the day trains stop at the station. Even at night you will find them there. Ten years ago the writer bought some ollas there at night. Although artistically decorated and of graceful shape, and superior to some other potteries, it has not the compactness, coherence and ring of the Acoma pottery, where they have the knack of firing their ovens more successfully. The town is really built of two-storied adobe houses that have flat roofs. It is built on the top of a slight eminence of light-colored sandstone, and the constant tread for many years of moccasined feet has worn a pathway or depression up the slight slope leading to the village. The dwellings are mud houses and not stone. The dwellings of Pueblo Indians differ according to location. In the cañons and on the steep mesas the houses are generally built of stone, which was abundant everywhere, but in the open country the houses were built of mud and pebbles, known as grout or cajon, a puddled mass, which was sun-dried before another layer was put on. Sometimes the structure was rendered firmer by horizontal or upright beams or poles. The women of Laguna are neatly dressed. They wear buckskin moccasins and blue dresses of ancient pattern. The men of Laguna wear a more modern costume and have no use for the more ancient dress. In the journey from Laguna to the Enchanted Mesa and Acoma we were accompanied by Mr. Marmon's son, who was educated at Carlisle. The journey takes from three to four hours, depending upon the kind of conveyance. Acoma, the cliff city, is but three miles beyond the Enchanted Meca, and they both lie in what is called a very wide cañon-like valley, with a more or less level floor in a plateau, in the young state of dissection, as the physiographers say. In other words, it is simply a grassy trough covered with gramma, and it has been carved from the plateau by erosion. It is more than ten miles long and from

two to four miles wide, and is surrounded by vertical walls. The few writers who have written about this valley have merely called it a trough. What is needed is an exact topographic term, the mere mention of which will explain it exactly. This may seem a small matter to the layman, but the use of exact physiographic terms is important. Captain C. E. Dutton, in his article on Mount Taylor and the Zuni Plateau, (6th Annual Report U. S. Geological Survey) says: "Did it ever occur to the reader how poverty-stricken the (I will not say English exactly, but) Anglo-American language is in sharp, crisp, definite topographic terms? English writers seem to have gathered up a moderate number of them, but they got most of them from Scotland within the past thirty or forty years. They are not a part of our legitimate inheritance from the mother country. In truth, we have in this country some three or four words which are available for duty in expressing several sources of topographic characteristics. Anything that is hollow we call a valley; anything that stands up above the surrounding land we call a hill or mountain; but the Spanish or Mexican, if you prefer, is rich in topographic terms which are delightfully expressive and definite. There is scarcely a feature of the land which repeats itself with similar characteristics that has not a pat name." This may seem a rather radical statement to make, but Dutton wrote in 1885, and modern physiography was in its infancy then. There were practically no text books on physiography in use in our colleges then. Now there are excellent text books on the subject and our modern geologies have a chapter on physiographic geology. Physiography is practically a new science. It must be remembered also that England has a moist climate and is not at all arid, hence topographic terms which apply to an arid region were unknown there. The Spanish settled the Southwest and gave expressive names to the topographic features of an arid region. The excellent publications of the U. S. Geological Survey, which are a credit to the country and are praised as much in Europe as they are at home, treat physiography from a modern standpoint. This may seem a digression, but it is more important than scaling the mesa. Dutton was undoubtedly right, and Robert F. Hill, of the U. S. Geological Survey, has emphasized this want of physiographic terms in an article in National

Geographic Magazine, Vol. vii, page 291. He was formerly geologist for Texas, where Spanish names predominate, and he soon recognized their efficiency as topographic terms. Among one hundred or more some have become incorporated permanently in our physiographic literature. Among the most common are mesa—a dissected plateau or tableland; cuesta—an inclined plain or declivity, a tilted plain; arroyo—a dry stream course; sierra—a mountain range with serrated crest; cordillera—used in a collective sense for a number of mountain ranges; rio—a flowing river; rio chiquito—little river, for example, Colorado Chiquito, a branch of the Colorado known as Little Colorado; canyon—precipitous gorge cut by a river and other erosive agents; cajon—a box cañyon; plaza—not the popular meaning, an enclosed square in a city. The Mexicans use this term for a valley resembling a canyon in that it is bordered by sub-vertical walls, but differs in that its bottom instead of being narrow is of great breadth. This latter term would seem to describe the valley in which the Enchanted Mesa is located, but the author's description of it as a wide canyon-like valley with a more or less level floor, is sufficient. Throughout the canyon floor we find many curious and bizarre forms of erosion which are noticed in an arid region where we have horizontal layers of sandstone and shale. Towers, peaks, minarets, and castle-like forms, due to differential weathering, are common and remind one of the Garden of the Gods. It is truly an enchanted valley. This has lead Mr. Chas. Lummis, who has done much to popularize the Southwest and its inhabitants in his interesting books to say in rather vigorous language, "That it is the Garden of the Gods multiplied by ten, with ten equal but other wonders thrown in, plus human interest plus archæological value and an atmosphere of romance and mysticism." Mr. Hodge, of the Bureau of Ethnology, quotes this and endorses the above description and says the comparison is not overdrawn. (See National Geographic Magazine, Vol. viii.) The latter part of the description is correct, but in the Garden of the Gods some of the strata have a very steep dip, in fact almost stand on edge, and hence some of the forms of erosion are more bizarre and fantastic. The Acoma Indians who live on the high mesa with precipitous walls, three miles beyond the Enchanted Mesa, have a tradition

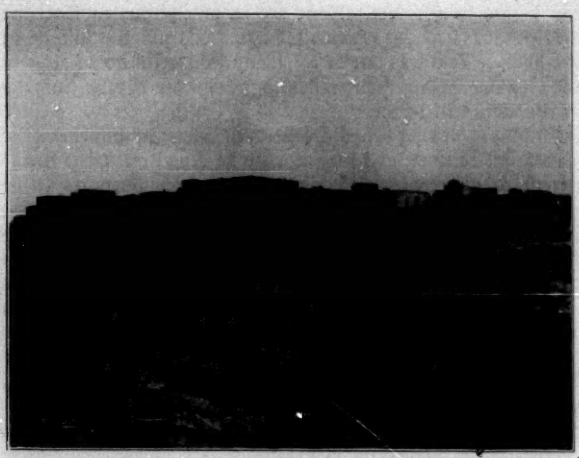
that the Enchanted Mesa was formerly inhabited by their ancestors. Many years ago a storm arose and an enormous rock near the top was loosened and came crashing down, thus destroying the trail and all access to the mesa, leaving some old women of the tribe to starve. The mesa was accursed Katzimo on account of the storm, and the Indians say it must not be ascended. The credit of discovering this tradition is generally given to Bandelier, whose work among the Indians is celebrated. Mr. Lummis claims priority (in Science, October 25, 1897), and states that he first published a skeleton of the legend in 1885. It was years later, he states, before he could round out the story. In the Catholic World (for January, 1873) is a very entertaining sketch of a journey to Acoma. Whether the writer learned of this tradition from the Indians he does not state. Prof. Libbey, of Princeton, was the first man to scale the mesa, which is nearly 500 feet high. This was done by shooting a rope over with a cannon. The descent was then made by a breeches buoy, such as the life-saving guard use along the coast. He stated that he found no indication of its being inhabited. Mr. Hodge, of the Bureau of Ethnology, then ascended the mesa, using spliced ladders. He found sherds of pottery, stone axes, a shell bracelet and a pile of stones, called a cairn. The discussion was taken up by the newspapers and magazines *pro* and *con*, and was participated in by a number of authorities. The author wants to do justice to all of these men, who have done excellent work in their respective fields. So that in order to be fair he will quote their views *verbatim*. Prof. Wm. Libbey, the well-known geographer and traveler, states (in Harpers' Weekly, Vol. xxxxi, page 862), "While the men at Acoma were away in July, 1897, piously engaged in cutting timber to renew the crumbling roof of their church, another party of men, headed by two vandals, one was a scientist, Libbey, the other a journalist named Bridgeman, ascended the mesa. We set the cannon up on the eastern side of the southern point of the mesa. The large shot was provided with a projecting shaft and ring. To this was attached a cord, which led to a box where a long line was carefully coiled in such a way that the line left the box without being snarled up. The shot passed up in the air high above the mesa and fell on the western side. We spent two days in

drawing ropes over the top of the rock until finally, by the aid of a team, the largest rope, about one inch in diameter, was pulled in place. This rope had a pulley attached to it, through which a smaller rope passed, and this pulley was hauled up exactly to the edge of the cliff. A curious seat was constructed with a board, which was suspended from a block which ran along the top of a large rope. One end of the smaller rope was attached to this block and the other fastened behind the team. The explorer seated himself in a chair and was drawn up to the top of the rock, and then another member, Pearce, was drawn up. We found ourselves upon the smaller end of the great rock and were cut off from the main portion of the mesa. We called for the ladder and climbed the mesa and wandered around for a long time, and when we came back to where we left our companions we called out to those below that the summit had never been inhabited; that there was no trace of houses ever having been constructed up there, and there were no remnants of pottery or fragments of household utensils or implements of any kind, no water-tanks for the storage of rain-water. One object alone looked as though it might have been built by human hands, and that was a small cairn like mass of stones. He spoke of stunted pine and cedar trees growing in scanty masses of earth here and there, but described the rest of the surface as perfectly bare and swept clean by the wind. A few grasses and plants, common on the plains below, were also found, and these, with one gray rat and a number of ordinary lizards, were all the evidences of life to be seen. All of which, he says, merely goes to show that he was in reality blinded by the spirits, and he remarked when he reached the plain once more that the mesa was disenchanted. It was an illusion of his mind that had been unduly excited by his trip up into the air only fit for spirits to breathe."

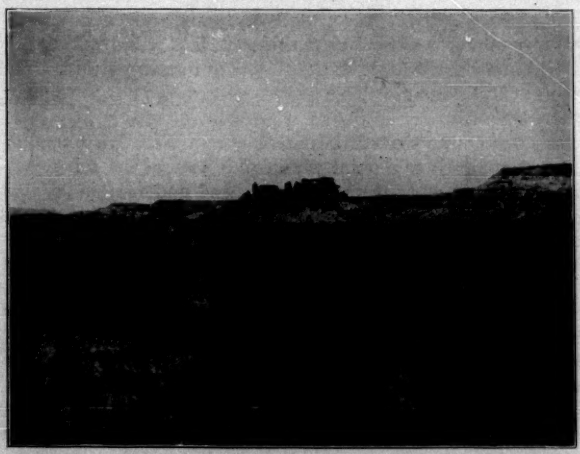
The following description and argument were written by Mr. Hodge (see Nature, Vol. lvii, page 450).

"Acoma is the oldest settlement within the limits of the United States. Many of the walls still standing were seen by Coronado in 1540. Even then they were centuries old. The valley of Acoma is described as the Garden of the Gods. It is a level plain, bounded by mesas, and is clothed and carpeted by gramma. The mesas are variegated sandstone rising precipi-

tously 300 to 400 feet. None are so precipitous as Katzimo or Enchanted Mesa, which rises 430 feet from the middle of the plain. This was one of the many wonderful home sites of the Acomas during their wanderings from the Mystic Shipapu in the far north to their present lofty dwelling place. Native tradition is distinguished from myth when uninfluenced by Caucasian contact, and may usually be relied on, even to the extent of disproving or verifying that which purports to be historical testimony. The Acoma Indians have handed down from Shaman to Novitiate, from father to son, in true prescriptorial fashion for many generations the story that Katzimo was once the homes of their ancestors, but during a great convulsion of nature at a time when most of the inhabitants were at work in the fields, an immense rocky mass became freed from the friable wall of the cliff, destroying the trail and leaving a few old women to perish. This tradition in its native purity was recorded twelve years ago (from 1898) by Mr. Chas. F. Lummis, and the same story was repeated by Acoma lips to Hodge while conducting a reconnaissance of the Pueblos in 1895. Hodge examined the talus especially where piled up high at the foot of the southwest cleft, up which the ancient pathway wound. It is covered with numerous fragments of pottery of a very ancient type, some of which was decorated by a vitreous glaze, an art, he states, lost to Pueblo potters. The talus at this point rises to a height of 224 feet above the plain, more than half way up the mesa could be formed only by earth washed from the summit during many centuries. His examination of the trail to a point within sixty feet of the top exhibited traces of what were evidently hand and foot holes that once aided ascent of the trail. He visited Katzimo a second time with Major George H. Pradt, Mr. A. C. Vroman and Mr. H. C. Hoyt. The ascent was made by ladders, and ropes and cameras and surveying instruments were carried with some effort, as the elevation above tide is 6000 feet, and they climbed in the hot sun. They fastened the rope to small pinions, where once was soil now found in the talus below. They soon found a sherd of pottery of an ancient type, plain gray ware, quite coarse in texture with a degraissant of white sand. The top of Katzimo is 2500 feet long. Great cedars grow gaunt and bare or lie prone and decaying. He was forced to the

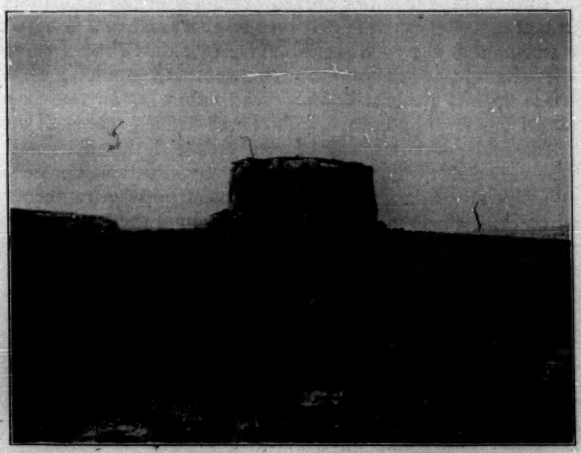


Indian Pueblo of Laguna, New Mexico



Weatered Castellated Rocks on Road to Acoma

View of Enchanted Mesa from Edge of Cliff at Acoma, Showing Other Mesas in the Distance



Enchanted Mesa—End View

conclusion that the house walls, stone or adobe, were washed from the summit, there being no possibility that a trace remained. Nevertheless the pottery in the talus and on top and the distinct remains of a ladder trail all testify to former habitation. To the Acomas, Katzimo is still enchanted and is a subject in the study of mysticism."

The following forceful argument by Mr. Hodge is found in Harpers' Weekly, Vol. xli, page 1027:

"The fact that we found on the summit two fragmentary stone axes and a portion of a shell bracelet, several greatly worn potsherds of extremely ancient ware and a projectile point would not in itself be regarded as conclusive evidence that the mesa had actually been occupied as a village site; but when we know that the summit is, and evidently long has been, inaccessible to the Indians, that it has been washed by rains and swept by winds for centuries until scarcely any soil is left on the crest, that thousands of tons of soft sandstone have so recently fallen from the cliff, that their edges have not had time to become rounded by erosion; that the typography of the summit is such that not a cupfull of water now remains on the surface, save in a few eroded potsholes in the sandstone, but that it rushes over the precipice on every side in a hundred cataracts; that the rude stone monuments that Prof. Libbey believed might be due to erosion in a spot well protected from surface wash is artificial beyond preadventure, as anyone may judge from my photograph. That well-defined traces of an ancient ladder way may still be seen pecked in the rocky wall at the very cleft through which the traditional pathway passed, and above all the large numbers of ancient pottery fragments and other artefacts in the earthy talus around the base of the mesa, which must have washed from the summit, for they could have occurred there in any other way, we have incontrovertible evidence that the summit of Katzimo or Enchanted Mesa was inhabited prior to 1540, when the present Acoma was discovered by Francisco Vasquez de Coronado, and that the last vestige of the village has long been washed or blown over the cliff. After having seen hundreds of ruins and engaged in excavating dozens of others in the Southwest, I am firmly convinced that there is ample archæological evidence of former occupancy of the Enchanted Mesa by the Acoma Indians, and

that their tradition to that effect is substantially true, and this opinion is entertained by every competent authority to whose attention these facts have been drawn."

George Wharton James, who has done much to popularize the Southwest in his interesting books, writes as follows (see Scientific American Supplement, Vov. xlvii, page 19,488):

"The evidence of human presence was found here all agree, but there is a vast difference between evidence of human presence and evidence of a large village or city.

(1). Had Acomas lived on the mesa they would have built houses not of adobe but of pieces of rock.

(2). Had such a city existed the ruined walls would have remained. Large blocks and pieces of sandstone would not have been eroded or washed away. The sloping conditions of the mesa not unusual. He makes a point that it would take a number of houses to store them and these houses would not blow away. Half a score or more of ruined cities exist on mesas storm swept and as exposed as the Enchanted Mesa, and yet the ruins are not swept away.

JAMES'S CONCLUSIONS.

(1). The mesa was undoubtedly the scene many times of human presence.

(2). Worn trail and other evidences clearly demonstrate that Indians have often visited it. These facts ought not to be accepted as conclusive evidence of the truth of the Acoma tradition that their ancient city was located there.

(3). Both Indian and white man are at fault in regard to the exact location of Katzimo, and that further researches will discover it and show far more positive and occular demonstration of its having been the occupied site of a larger city than the so-called Katzimo and Mesa Enchanted of the present discussion have done.

My reasons for advancing this last idea are:

(1). My firm belief in the general truth and reliability of the tradition.

(2). Unsatisfactory evidence adduced in favor of the village occupancy of the mesa hitherto known as Mesa Enchanted.

(3). My knowledge of the possibility of error both by Indian

and white man owing to the lapse of centuries in determining the location.

(4). My actual conversation with Indians at Acoma who definitely assert that the scaled mesa is not their Katzimo, and that may be so. Some day they will conduct me to the real, genuine, sole and only Katzimo or Mesa Enchanted, where many ruins are to be found."

From the above statements it is evident that opinions vary, but all must agree that the pottery, ax-heads and other remains prove beyond all doubt that the mesa was visited by Acoma or other Indians before the trail was destroyed. The author has visited the Southwest on different occasions and examined many ruins and pictographs or inscriptions in different localities, is prepared to believe the mesa was inhabited. In fact it would be very strange if such an impregnable Gibralter or fortress isolated in the desert would not be used as a habitation. It was an ideal site, just such a one as the Indians would select. More secure from the migratory Apaches and Navajos than the mesa at Acoma. We are prepared to believe that it was something more than a mere look-out station to warn then of the approach of their enemies as they came up the valley. We believe, however, that the houses were adobe or mud houses, and entirely swept away by the cloud bursts which we have experienced in the plateau region. If the houses were built of stone the walls undoubtedly would be standing, as they do on other mesas and in the open country. Walls of very ancient ruins, such as we have noticed even on the very edge of the Grand Cañon more exposed to erosion than on the mesa.

The statement has been made, "had the Acomas lived on the mesa they would have built not of adobe but of rock."

This does not, necessarily, follow because the houses at Acoma are built of rock and adobe. The old Spanish church is built of adobe, the walls being several feet in thickness. The enormous grave-yard, which took them forty-five years to build, is made of earth brought from the valley below. In regard to the statement that the glazing of pottery is a lost art with the Pueblo Indians, there is room for difference of opinion. The author has examined considerable pottery of the so-called ancient or Cliff Dwellers' type, both fragmentary and

whole, and has yet to see a piece which he considers has a true glaze. Briefly stated, the so-called fat clay is essentially silicate of alumina. A lean clay is silicate of alumina plus impurities, such as lime and the alkalies, potash and soda. These impurities come from the feldspars which produce the clay in nature by their decomposition. The tendency of these impurities is to make a clay slightly fusible or less refractory. If the temperature of a furnace or oven is too high, the clay is overburned and may vitrefy slightly on the surface, but we do not believe the temperature of these ovens with the kind of fuel the Indians use is ever sufficient to do this, and if it were possible it would not be a glaze.

Mr. Wm. H. Holmes, of the Bureau of Ethnology (4th Annual Report, page 268, Pottery of the Ancient Pueblos), says:

"A great deal has been said about the glaze of native American wares which exists if at all through accident. The surface of the white ware of nearly all sections received a high degree of mechanical polish, and the effect of firing was often to heighten this and give at times a slightly translucent effect, a result of the spreading or sinking of the coloring matter of the designs."

TOPOGRAPHIC MAPS OF THE GEOLOGICAL SURVEY.

How many persons would like a map of the district in which they live? Surely there are very many who would find convenient such a possession. To the people of many districts in the United States such a map—accurate, detailed, and of moderate size—is available for the small sum of five cents.

The United States Geological Survey is making a topographic map of the United States. This work has been in progress since 1882, and about three-tenths of the area of the country has been covered. The surveyed districts are widely scattered throughout the country. When the atlas is finally completed, every citizen of the United States may procure a federal map of his particular environment.

This great map is being published in atlas sheets of convenient size, which are bounded by parallels and meridians. The four-cornered division of land corresponding to an atlas sheet is called a quadrangle. The sheets are of approximately the same size, the paper dimensions being 20 by 16½ inches. Three scales, however, have been adopted. The largest scale of nearly 1 mile to 1 inch is used for thickly settled or industrially important parts of the country. For the greater part of the country an intermediate scale of about 2 miles to 1 inch is employed. A third and still smaller scale of about 4 miles to 1 inch has been used in the desert regions of the Far

West. A few special maps on larger scales are made of limited areas in mining districts.

The features shown on this map may be classed in three groups: (1) water, including seas, lakes, ponds, rivers, and other streams, canals, swamps, etc,; (2) relief, including mountains, hills, valleys, cliffs, etc.; (3) culture, that is, works of man, such as towns, cities, roads, railroads, boundaries, etc. All water features are shown in blue, relief is in brown, and cultural features are in black.

The sheets composing the topographic atlas are designated by the name of a principal town or of some prominent natural feature within the district.

They are sold at 5 cents each when fewer than 100 copies are purchased, but when they are ordered in lots of 100 or more copies, whether of the same sheet or of different sheets, the price is 3 cents each. Applications should be accompanied by the cash of by post-office money order (not postage stamps) and should be addressed to the Director United States Geological Survey, Washington, D. C.

THE WORLD'S MERCHANT MARINE.

Marine Engineering, of New York, has been comparing the growth of the American merchant marine with those of other nations, and in the course of an interesting article on the subject it is stated that "in no case does the American tonnage exceed 28 per cent. of that credited to Germany. Both France and Italy have a larger tonnage under construction that the United States, the differences running from 13,000 tons in the case of each of the above powers, to 35,000 tons in the case of Italy at a slightly more recent date, at which time even Holland exceeded the American construction by 8,000 tons. Aside from Great Britain." the article goes on, " there is not a single nation in the world which has naturally so great an interest in seaborne commerce as has the United States; not only are the latter's exports and imports immeasurably superior in both bulk and value to those of any other power, but the American coast line is enormous in extent, has many splendid harbors for the reception of ships, offers every facility which nature can offer for the proper development of a mercantile marine. It is simply a question of a difference in wages and in other operative costs between American ships and those of foreign nations. So long as this difference exists it will be manifestly impossible to operate American ships in direct competition with those of other powers, and this condition will persist just so long as American standards of living remain superior to foreign standards of living, and no longer.

"In other words the rehabilitation of the American merchant marine has come to be a question of either providing governmental assistance to shipbuilders and ship owners, or reducing the American scale of living to standards prevailing elsewhere in the world."—Chas. S. Lake, in *Modern Engineer*.

In Memoriam.

JOHN VAUGHAN MERRICK.

J. V. Merrick was born in Philadelphia, August 30th, 1828, and died at his home in Roxborough, Philadelphia, March 28th, 1906.

His parents were Samuel Vaughan and Sarah (Thomas) Merrick. The father's name is indelibly connected with the origin of the Franklin Institute, in 1824, as is fully described in the commemorative exercises of its fiftieth anniversary in 1874. S. V. Merrick's life was one of great activity and usefulness to the community. In addition to creating the works of the Southwark Foundry, he was the first President of the Pennsylvania Railroad. The first gas works in Philadelphia were built under his charge as engineer, in 1835. He was President of the Franklin Institute from 1841 to 1853, and until his death he was deeply interested in the success of this institute.

Yours truly
J. Vaughan Merrick

His eldest son, J. V. Merrick, the subject of this sketch, was graduated from the Philadelphia High School in 1843, being the youngest pupil, with one exception, ever admitted to this school. The same year he entered the works of Merrick and Towne as an apprentice, and was trained in the manual arts of the various mechanical departments. In 1849, he became the

head of the firm of Merrick & Son's, and soon was recognized as one of the leading mechanical engineers of the city.

For the following twenty years his energies were devoted to the development of the manufacturing industries of the Southwark foundry. The works were enlarged, and its products further diversified. During the strenuous period of the civil war Mr. Merrick devoted his workshops, as well as his own personal services, to the nation's cause. His experience as a designer and constructor of steam machinery for ships was recognized by his selection by the Navy Department, in 1862, as a member of the Board of Experts to report on naval machinery.

Among the more important of his productions and of his works, which were put into successful operation, was the motive machinery for the following steamships: North Carolina, Cardenas, Quaker City, North America, Phineas Sprague, Alphonso, Continental, and also a number of tug boats for river and harbor service.

Among the prominent war ships built for the U. S. Navy were the machinery for the San Jacinco, Wabash, Yantic, Wyoming, Yazoo, New Ironsides. The latter being the first of our iron clads. The machinery for several revenue cutters and light draught monitors were also produced at his works during the civil war. The works also acquired a high repute for their miscellaneous products, such as pumping and blowing engines, the machinery for gas works, and apparatus used in sugar refining, &c.

He designed and patented a novel form of steam hammer, in which the steam cylinder was embraced in the moving ram, and steam supplied through a hollow stationary piston rod.

In recognition of his experience and ability Mr. Merrick was appointed in 1883, a member of the Board of Experts to report on improvements in the water supply for Philadelphia.

In 1870, owing to impaired health, he retired from active business, and devoted his remaining years largely to philanthropic work.

His zeal and activity in this line of duty were incessant to the close of his career. Always of a deeply religious nature, and recognizing in the church a most potent instrument for elevating the morals of the community, he advocated its cause

with his efforts and his means,—by the most practical and efficient methods.

In 1873, he was instrumental in founding St. Timothy's Working Men's Club and Institute, Roxborough, an organization designed to furnish recreation and instruction, for a small fee, to that large class, who most need it. He devoted much of his time and energy to the interests of this institution, which still exists and has proved most beneficial to the neighborhood. In 1890, he and his wife founded St. Timothy's Hospital and House of Mercy, Roxborough, giving the land and the original buildings, together with a substantial endowment for its support, and he labored constantly for its development until his death.

The following list of offices held by Mr. Merrick, and in most of which he was an active worker, are indicative of his active and useful life:

Director of the Zoological Society since its origin, and Vice-President since 1886.

Trustee of the University of Pennsylvania since 1870; was senior trustee at his death; member of Committee on University and chairman of the Standing Committee on "Department of College and Philosophy."

Incorporator of the "Wagner Free Institute of Science," in 1864. Trustee from 1885 to 1894.

Trustee of the Episcopal Academy from 1874 to 1898.

Member of Board of Managers of the Episcopal Hospital and Chairman of the Building Committee from 1876 to 1900.

Vice-President American Society of Mechanical Engineers 1883-1885.

Delegate to the convention of the P. E. Church diocese of Pennsylvania since 1861, and for twenty-five years one of the four lay deputies to the triennial convention of the P. E. Church.

Since 1870, Trustee of the "Society for the Advancement of Christianity," State of Pennsylvania.

For over thirty years a director of the "Society for the Relief of Widows and Orphans of Deceased Clergy of the P. E. Church."

One of the founders of the "Free and Open Church Association," and President of it since its origin, in 1873.

Mr. Merrick was elected a life member of the Franklin Institute in 1849. Was a member of the Board of Managers from 1864 to 1884. President of the Institute for the three years, 1867-68-69, and a member of the Board of Trustees from 1887 to 1895.

He contributed the following papers to the *Journal* of the Institute.

"Evaporative Efficiency of Martin Boilers".....lxi, 357
"Friction of Marine Steam Engines".....liii, 132
"History and Construction of Iron Lighthouses".....lxi, 145
"Marine Propulsion".....liii, 270, 417
"Mode of Increasing Draft in Marine Boilers".....lviii, 390
"Notes on Steamship 'State of Georgia'".....liii, 407
"Particulars and Performance of Steamship 'North Carolina'".....lviii, 411
"Screw and Engine of U. S. Steamship 'San Jacinto'".....liii, 50
"Steamboats on Western Waters".....liii, 344
"Trial Trip of the Steamship 'Quaker City'".....lviii, 269
"Use of Cornish Engines for the Water Supply of Cities".....lxxxviii, 229
"City Avenue (Schuylkill)Bridge".....cxxxix, 241

At the University Day exercises, held on February 22, 1906, the Trustees of the University of Pennsylvania conferred the honorary degree of Doctor of Science upon Mr. Merrick. In presenting the candidate to the Provost for this degree, Dr. S. Weir Mitchell said in part:

"Distinguished as an inventor and expert in many forms of industrial machinery, the nation owes him a debt of gratitude for the skill, the speed and the perfection shown in the construction of the engines needed for our ships during our civil war and in a time of utmost emergency. The honor we offer is also meant to express our appreciation of Mr. Merrick's thirty-six years of varied services to this University and of the rare personal qualities of which I spare him the gracious enumeration."

JAMES CHRISTIE.

HIGH KITE FLYING.

The highest kite ascent yet recorded was made at the æronautical observatory at Lindenberg (Prussia) on November 25th 1905, 21,100 feet being attained. Six kites were attached to oneanother, with a wire line of nearly 16,000 yards in length. The minimum temperature recorded was 13 deg. F.; at starting the reading was 41 deg. The wind velocity at the surface of the earth was eighteen miles an hour, and at the maximum altitude it reached fifty-six miles an hour. The previous highest record by a kite was nearly 1,100 feet lower, and was obtained from a Danish gunboat in the Baltic.—*Model Engineer.*

Book Notices.

Morton Memorial: A history of the Stevens Institute of Technology with biographies of the faculty, trustees and alumni, and a record of the achievements of the Stevens family of engineers. Edited by Franklin De Ronde Furman, M.E., Professor of Mechanical Drawing and Designing; with an introduction by Alexander Crombie Humphreys, M.E., Sc.D., LL. D., President of Stevens Institute of Technology. (4 to., pp. 641, with preface and introduction. Hoboken, N. J. Stevens Institute of Technology, 1905.

This superbly printed and illustrated volume was originally planned as a souvenir to commemorate the twenty-fifth anniversary of the Stevens Institute of Technology. The idea of the volume originated with the President, Henry Morton, who was deeply interested in its publication, but his lamented and untimely death occurred before the work was completed. It appeared later, designated most appropriately the "Morton Memorial."

To all who know the history of this floursihing and progressive institution, the generous tribute paid to the memory of its first President will be cordially endorsed. President Morton devoted the best years of his life to the development of the institute, and the foremost rank which it now occupies among the technical schools of the country is largely due to his ability as an organizer and administrator, no less than to those personal qualities, which enabled him to attract and enlist the coöperation of men of the highest professional standing to second his efforts in developing the strength and influence of the Institute.

Stevens Institute, to-day, is a monument to his memory—in the words of a resolution adopted by its Trustees—"more enduring than 'marble, or the gilded monuments of princes.'"

The friends of Stevens will find the present handsome memorial volume a complete history of the Institute from it origin. Included therein is a series of chapters devoted to the history of the achievements of the famous Stevens family, several of whom attained high repute as engineers, and one of whom (Edwin A. Stevens) was the founder of the Institute which bears the family name.

Following, are given biographies of the trustees, the faculty and the alumni.

The work is profusely illustrated with admirably executed engravings.

Taken all together, it is a publication highly creditable to all who have contributed to its production. W.

Sections.

Electrical Section: *Stated meeting*, held Thursday, May 17, 8 P.M. Mr. James Christie in the chair.

Present, twelve members and visitors.

Dr. Frederic A. C. Perrine, of New York, read the paper of the even-

ing on "The Value and Design of Water-Power Plants as Influenced by Load Factor."

The paper was freely discussed by Messrs. Hering, Christie, Foster and the author.

The thanks of the meeting were extended to the speaker of the evening, and his paper was referred for publication. Adjournd.

RICHARD L. BINDER, *Secretary*

Franklin Institute.

(Stated Meeting, held Wednesday, May 16th, 1906.)

HALL OF THE INSTITUTE,
PHILADELPHIA, May 16, 1906.

MR. JAMES CHRISTIE in the chair.

Present, seventy-six members and visitors. Additions to membership since last report, eight.

The resignations of Messrs. William H. Lambert and C. Hartman Kuhn from the Board of Managers were reported.

Messrs. Coleman Sellers, Jr., and Samuel M. Vauclain were thereupon chosen to fill the vacancies.

The chairman then introduced Dr. Henry Emerson Wetherill, of Philadelphia, who presented an interesting account of "The Panama Canal," in which he dwelt specially on the the engineering and sanitary features of the work. The speaker's remarks were freely illustrated with the aid of lantern pictures.

Through the courtesy of Messrs. Williams, Brown and Earle, of Philadelphia, a series of lantern views of San Francisco were shown, exhibiting the destruction wrought by the recent earthquake.

Adjourned.

WM. H. WAHL, *Secretary.*